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Fire Prevention and Protection

THE SPECTATOR COMPANY

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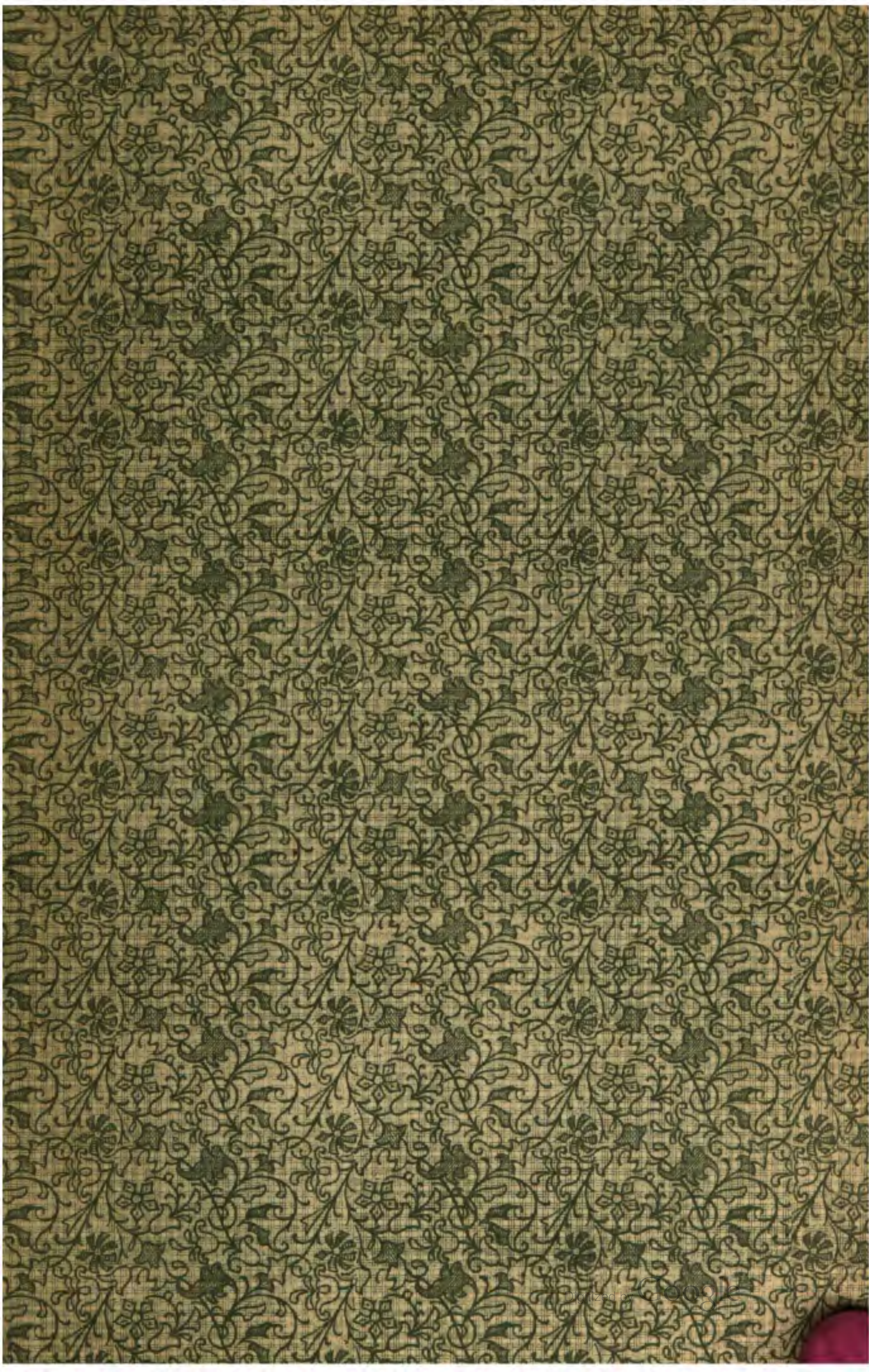

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FIRE PREVENTION

AND

PROTECTION

A COMPILATION OF INSURANCE REGULATIONS COVERING MODERN RESTRICTIONS ON HAZARDS AND SUGGESTED IMPROVEMENTS IN BUILDING CONSTRUCTION AND FIRE PREVENTION AND EXTINGUISHMENT

THIRD EDITION

COMPLETELY REVISED BY
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FIRE PROTECTION ENGINEER

1916

THE SPECTATOR COMPANY

CHICAGO OFFICE:
INSURANCE EXCHANGE.

135 WILLIAM STREET,
NEW YORK.

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PREFACE

In the preparation of this book it has been the aim of its publishers to place before merchants, manufacturers and underwriters, as succinctly and conveniently as possible, the knowledge necessary to the most thorough protection from fire and its consequent danger, trouble and loss; in addition it is believed that it will be of great value to fire departments, as in no other book are the various protective features to be found so completely set forth. There are many methods by which the physical hazard of mercantile and manufacturing establishments may be so improved as to materially lessen the liability to fire, and also to command considerable reductions in premium rates for insurance. The latter consideration will appeal strongly to those who have been accustomed to exercising the utmost care in the preservation of their property in ordinary ways, but who would not care to go to the expense necessary to the fullest protection without the practical recognition of their effort and outlay in the form of a lessened expense for premiums.

The plan of this work includes the presentation of references to the various materials and devices which have been found useful in preventing or extinguishing fires, accompanied by such information as will enable a property owner to be guided in the use of approved appliances and materials. It covers all suggested regulations of the National Board of Fire Underwriters and its allied organizations, concerning the matters treated in this book.

Embodied in this work will be found a considerable amount of miscellaneous information, all tending to give a clearer understanding of matters connected with the prevention and extinguishment of fire.

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Little of the text of this book can be claimed as being strictly original, as the subjects treated have received exacting study by the various organizations from whose reports and regulations they have been compiled. In particular, credit is given to the National Board of Fire Underwriters for the use of authoritative cuts and permission to reprint various articles and regulations, with especial reference to the copyrighted pamphlet on *Fire Engine Tests and Fire Stream Tables,* and the suggestions contained in the *Building Code.*

In the hope that its contents will assist in producing a reduction of the annual fire loss, thereby benefiting both those who buy and those who sell insurance, this book is respectfully submitted to the public.

THE SPECTATOR COMPANY.

New York, September 1, 1916.

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ORGANIZED FIRE PREVENTION

Chief Fire Causes.—Fire insurance companies have realized for many years that most of the fires are caused by improperly installed appliances or wrongful use of materials, and that the seriousness of fires is often due to faulty construction, which permits an early collapse of a building or the rapid spread from one floor to another or to adjoining buildings.

Fire Prevention a Duty.—Primarily it is the duty of the individual or the State to provide the regulations necessary to prevent such occurrences and only the business of the insurance company to indemnify the owner, and to charge a sufficiently high premium for each class of business to cover the loss and pay a moderate return on the company's capital.

Even in the early days of fire insurance the companies realized that to reduce the gamble, by reducing the probability of fires, a greater net profit would be obtained during a long period of time. The companies have for years, in line with this policy, maintained men who made a special study of prevention of fires and who would give advice to prospective customers.

Confusing Advice.—With the expanding of American industries, plants became too large for one or two companies to underwrite the entire risk involved, and other companies would be called upon to take their share. This resulted in each company advising the owners as to the best means of protection and prevention, with great confusion when attempts were made to carry out the various requirements, as each engineer had his own idea as to what was best.

Organized Effort.—To offset this, various committees of interested insurance officers have been organized from time to time to formulate suggestions and regulations; at the present time, as a result of this, two organizations are in existence primarily for this purpose. One of those is the National Board of Fire Underwriters and the other is the National Fire Protection Association.

National Board of Fire Underwriters.—The National Board of Fire Underwriters is an organization of practically all of the stock fire insurance companies; it operates through committees, on which are executive officers of the company members, and has an office, under the supervision of a general manager, at 76 William Street, New York. Of the various committees, the following are the more important: The Committee on Fire Prevention, which, through a corps of trained engineers, investigates and reports on the general features of fire protection and conflagration hazard of cities; the Committee on Laws, which keeps the companies informed of legislation affecting them, and through publicity strives to prevent unfair requirements being enacted; the Committee on Building Construction, under whose guidance a model building code has been drawn up and efforts made to get the various cities to adopt it; the Acturial Committee, which has recently started a compilation of all fire losses in the United States, and the Committee on Lighting, Heating and Patents, which supervises the issuing of suggested regulations covering various appliances and features of construction.

Regulations Issued by the National Board of Fire Underwriters.

Acetylene Gas Machines and Oxy-Acetylene Heating and Welding.
Blower Systems.
Cans—Waste and Ash. (Out of print.)
Chemical Fire Extinguishers. (Out of print.)
Coal Gas Producers. (See Internal Combustion Engines.)
Code—Building.
Code—Electrical.
Code—Electrical Fittings.
Containers for Hazardous Liquids.
Dip Tanks.
Doors, Fire. (See Protection of Openings.)
Fire Alarm Systems—Municipal.
Fire Brigades—Private.
Fire Doors. (See Protection of Openings.)
Fire Pails. (Out of print.)
Fuel Oil—Storage and Handling.
Gasolene Stoves. (Out of print.)
Gasolene Vapor Gas Lighting Machines.
Gas Shut-off Valves.
Grain Dryers. (Out of print.)
Hose Couplings and Hydrant Fittings.
Hose Houses for Mill Yard Use.
Hose—Unlined Linen. Out of print.
Hydrants—Mill Yard. (Being revised.)
Internal Combustion Engines and Coal Gas Producers.
Kerosene Oil Pressure System. (Out of print.)
Lightning—Protection Against.
Mill Construction. (Out of print.)

NOTE.—Regulations dealing with the construction of appliances are no longer issued by the National Board of Fire Underwriters, but can be obtained by interested manufacturers from the Underwriters' Laboratories.

Motion Picture Films—Storage and Handling.
Oil Rooms. (Out of print.)
Oxy-Acetylene. (See Acetylene Gas Machines.)
Protection of Openings in Walls and Partitions.
Pumps—Centrifugal—Rotary—Electric.
Pumps—Steam.
Pumps—Steam Governors.
Railway Car Storage.
Signaling Systems. (Being revised.)
Skylights.
Sprinkler Equipments.
Tanks—Gravity and Pressure.
Valves and Indicator Posts.
Vaults.
Walls and Partitions—Protection of Openings in.
Windows—Fire. (See Protection of Openings.)
Wired Glass. (Out of print—See Protection of Openings.)

List of Suggested State Laws and City Ordinances issued by the National Board of Fire Underwriters. For use by State and City Officials in framing regulations on matters pertaining to Fire Prevention

State Laws

To Regulate the Manufacture, Storage, Sale and Distribution of Matches.

To Regulate the Transportation and Carriage of Explosives.

To Regulate the Manufacture, Storage, Sale and Use of Explosives.

To Establish the Office of State Fire Marshal.

City Ordinances

To Regulate the Installation, Operation and Maintenance of Motion Picture Machines, and the Construction and Arrangement of Picture Machine Booths and Audience Rooms.

To provide for the Inspection of Premises by the Fire Department, accompanied by a blank form for use by the inspector.

To Regulate the Manufacture, Storage, Sale and Distribution of Matches.

To Regulate the Manufacture, Keeping, Storage, Sale, Use and Transportation of Explosives, in Cities whose population exceeds 100,000 inhabitants.

To Regulate the Manufacture, Keeping, Storage, Sale, Use and Transportation of Explosives, in Villages or in Cities whose population does not exceed 100,000 inhabitants.

To Prohibit the Discharge or Firing of Fireworks.

To Regulate the Use, Sale and Storage of Fireworks.

To Govern the Construction and Operation of Laundries.

To Regulate the Construction and Equipment of Theatres.

To Regulate the Use, Handling, Storage and Sale of Inflammable Liquids and the Products Thereof.

A Code of Abbreviated Ordinances for use of Small Municipalities, and containing under one cover, ordinances providing for Fire Limits, and the Construction and Equipment of Buildings; The Regulation of Automobile Garages; The Regulation of the Equipment and Operation of Picture Machines and Premises wherein the same are operated; The Inspection of Premises by the Fire Department; the Cleanliness of Streets, Alleys and Premises; The Burning of Refuse; The Storage of Explosives; Fire Escapes, and Prohibiting the Discharge or Firing of Fireworks.

A Model Building Code, covering all features of building construction, including Theatres and Tenement Houses.

National Fire Protection Association.—Cooperating with the National Board of Fire Underwriters is the National Fire Protection Association. This association originally included only those organizations and societies interested in underwriting, but in latter years its membership has broadened to include all institutions, societies, associations, departments and bureaus interested in the protection of life and property against loss by fire, with associate membership for any individual paying dues. This association has two functions, to educate the people as to the economic advantage in preventing fires and to formulate suggested requirements as to the best means of accomplishing this and of the proper extinguishing appliances necessary.

Personal Responsibility for Fire Loss.—In a pamphlet dated March, 1914, the National Fire Protection Association issued a suggested bill for adoption by State legislatures, reading as follows:

SUGGESTED BILL TO FIX PERSONAL LIABILITY FOR FIRES DUE TO CARELESSNESS OR NEGLECT

SECTION 1. Any person, persons or corporation for any fire caused by, resulting from, or spreading by reason of the negligence of such person, persons or corporation or the non-compliance with any law or ordinance or lawful regulation or requirement of or by any state or municipal authority, shall be liable: (1) for all loss, expense or damage caused by or resulting from such negligence or non-compliance; and (2) for any expense incurred by any municipal or other governmental agency in extinguishing or attempting to extinguish any fire so caused, resulting or spreading.

SECTION 2. In all actions against any person, company or corporation for the recovery of damages on account of any loss or injury to any property, real or personal, occasioned by fire communicated from property owned by one party to property owned by another party, the fact that such fire was so communicated shall be sufficient evidence to charge the occupant of the property in which the fire originated with negligence, and place the burden of proof upon him.

In connection with the above, Charles E. Meek, then president of the National Association of Credit Men, said:

The American fire loss in 1914 amounted to nearly $236,000,000, the largest in the history of the country, with three exceptions, namely, 1908, the year of the Chelsea fire, 1906, when San Francisco was destroyed, and 1904, when Baltimore suffered. Compare these figures with those showing the loss through business failures and you will begin to appreciate the fact that the fire loss was nearly as much as, if not more than, that caused through commercial disasters, this for the reason that there is a considerable amount of salvage to be secured from the assets of those who fail, while the figures setting forth the fire loss show the amount actually destroyed. There was only one conflagration during 1914, representing a loss of about $13,000,000, the balance of the loss being distributed pretty equally throughout the country, which bears striking testimony to the carelessness of the American people, because it is a well-known fact that a great majority of the fires could be prevented were proper care exercised And don't forget that a great many lives are sacrificed annually through fire, whereas business fatalities result only in the loss of dollars and cents. I read a few days ago that in one city over one hundred and sixty-eight lives were lost during the year through fire.

The question which now naturally arises is: What can be done to reduce the annual fire and bad debt losses? Regarding the first, until some severe penalty is laid upon those whose carelessness is the cause of fire damage to the property of their neighbors, there will be no reduction in the size of our annual bonfire. It is welcome news to hear that the National Fire Protection Association has drafted a bill which will be introduced into the legislature in every state, and which, if enacted, will penalize the individual whose carelessness has damaged the property of others. The members of the National Association of Credit Men can, as individuals, aid materially in reducing the fire loss and at the same time set a good example to their neighbors through personally inspecting their places of business and their homes at regular intervals, for the purpose of ascertaining whether the ordinary precautions against fire are being exercised. You may not know it, but a very large percentage of all the fires occurring in this country originate in the rubbish heap.

The Elimination of Fire Hazards.—To lessen this preventable loss the first mentioned function of the National Fire Prevention Association, that of preparing suggested requirements, is of vital importance; seldom does a property owner realize the hazard of the conditions existing around his plant, and even if he appreciates the hazard, he may not know of the best way to abate it. These regulations, the majority of which are embodied in this book, are prepared by committees composed of insurance men, as well as men in daily contact with the conditions being discussed, are then passed upon by the association as a whole and by the executive committee, and are adopted and printed by the National Board of Fire Underwriters. The following list covers the subjects on which regulations have been issued, copies of which can be obtained from any insurance organization or direct from the National Board of Fire Underwriters at 76 William Street, New York.

Membership in the National Fire Protection Association, which entails an annual fee of $5.00, insures receiving a copy of all later editions of any regulations already issued and of regulations on new subjects; it also includes a quarterly publication which gives interesting articles dealing with fire prevention and protection, and statistics on fires in various classes of manufacturing risks. This association has lately included in the work of some of its committees the question of safeguarding life as well as property. For plant managers and others interested, it is advised that an application for membership be sent to the Secretary of the National Fire Protection Association at 87 Milk Street, Boston, Mass.

The Underwriters' Laboratories.—Manager W. H. Merrill has prepared a description of the purposes and work of the Underwriters' Laboratories, much of which is presented herewith:

Underwriters' Laboratories, a corporation chartered November, 1901, by the State of Illinois, is authorized to establish and maintain laboratories for the examination and testing of appliances and devices, and to enter into contracts with the owners and manufacturers of such appliances and devices respecting the recommendation thereof to insurance organizations.

The corporation is not in business for profit. Its chief financial support is received from the National Board of Fire Underwriters, under whose general direction the work is carried on. The members of the Board of Directors of the corporation are chosen from the officers of the National Board of Fire Underwriters and other organizations of Underwriters from which donations of money are received.

The work of Underwriters' Laboratories is confined to investigations having a bearing upon the fire hazard, and is undertaken as one means of securing correct solutions of many of the problems presented by the enormous and disproportionate destruction by fire of property in the United States.

OPINIONS OF EXPERTS.—The object of Underwriters' Laboratories is to bring to the user the one best obtainable opinion on the merits or demerits of appliances in respect to the fire hazard. Such appliances include those designed to aid in extinguishing fires, such as automatic sprinklers, pumps, hand fire appliances, hose, hydrants, nozzles, valves, etc.; materials and devices designed to retard the spread of fire, such as structural methods and materials, fire doors and shutters, fire windows, etc.; and machines and fittings which may be instrumental in causing a fire, such as gas and oil appliances, electrical fittings, chemicals and the various machines and appurtenances used in lighting and heating.

THE LABORATORIES' PLANT.—The principal offices and testing station of Underwriters' Laboratories, Inc., are located at 207 East Ohio St., Chicago. Branch offices are located in thirty-two other cities of the United States and Canada. The New York office is equipped for the conduct of examinations and tests of all electrical devices under the same conditions as those afforded at the principal office and testing station in Chicago. The Chicago plant occupies a three-story and basement building of fireproof construction containing something over 45,000 square feet of floor space, with a frontage of two hundred and sixty-six feet. Yard space is provided for huts and large testing furnaces. The main building in Chicago is, perhaps, the best example in America of absolutely fireproof construction furnished with fireproof finish and equipment. Brick, terra cotta, concrete, stone, steel and iron, are used exclusively in the structural features. The window frames and sash are of metal with wired glass, the doors are of metal, the desks and filing cases in the main office are of steel, and even some of the picture frames are of the same material. No wood or other combustible material is used in any portion of the finish. In addition, the plant is equipped with automatic sprinklers, and the lighting and heating hazards are safeguarded with every known precaution applicable to their installation in buildings of frame construction. In this model building the Underwriters have gone to the extreme in adopting in their own property all the measures they are known to recommend in the property of others. Eighty-three persons are employed in the Chicago plant, which, with its equipment, has a value of approximately $175,000.00.

TESTS.—The specifications under which the experimental work is carried on are based upon the Rules and Requirements of the National Board of Fire Underwriters as recommended by the National Fire Protection Association. The technical work at the Laboratories and the promulgation of the findings in the Laboratories' reports are under the supervision of the Council of Underwriters' Laboratories.

REPORTS UPON TESTS.—Summaries of the Laboratories' reports are promulgated on printed cards filed according to classifications, and cabinets containing these cards are maintained at the offices of the principal Boards of Underwriters and Inspection Bureaus in the United States, at many of the general offices of insurance companies, by some insurance firms, certain municipal departments, and at the local offices of the Laboratories in larger cities. Much of the information is also freely distributed by means of lists of manufacturers of inspected appliances promulgated by the Laboratories, and the results of the work in many classes of appliances are furnished directly to building owners, architects, users and all other persons interested, by means of the Laboratories' Label service, under which goods are inspected at factories by Laboratories' engineers and stamps or labels attached to such portion of the output as is found constructed in accordance with standard requirements.

The aim of the founders of Underwriters' Laboratories to secure the best and fairest opinion regarding the merits or demerits of every device, system or material having a bearing upon the fire hazard, and to have the work so conducted and reviewed as to secure accuracy and uniformity in its findings, has been accomplished to such an extent that the majority of fire Underwriters in the United States, many municipal authorities, and a large number of architects, building owners and users either accept or require a report from these Laboratories incident to their recognition of devices, systems and materials having a bearing upon the fire hazard.

Underwriters' Laboratories, Inc., however, issues no guarantee that its findings will be accepted or recognized in any case. Such assurances can only be obtained from the authority having jurisdiction.

PROPRIETARY ARTICLES.—As manifestly the regular subscribers to the Laboratories cannot be called upon to cover the expenses of tests made at the request of others, a system has been established whereby a manufacturer or owner desirous of securing an examination and report by the

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Laboratories on any particular device, system or material, is enabled to do so by first depositing a preliminary fee as evidence of good faith, and on completion of the work paying the balance of its cost as shown by accurate records thereof, which are kept in detail. As a warrant that an applicant will not incur costs beyond his expectations, a limit of expense is fixed in each case beyond which charges are not made. By this means an opportunity is afforded anyone at comparatively low cost to secure the opinion of the recognized authorities covering any device, system or material in its relation to the fire hazard.

The amounts of the fees are in proportion to the nature and extent of the work required in examinations and tests.

The cost of experimental work is practically the same in each class of device, whether samples show superior or inferior qualities.

The applicant's obligation to pay the charges is not, therefore, contingent upon the nature of the opinion rendered,—whether favorable or otherwise.

The schedule of charges found necessary in the different branches of the work is arranged by groups as follows:

	Amount of Preliminary Fee	Total cost to Applicant not to exceed
Group A	$100.00	$250.00
" B	50.00	100.00
" C	25.00	75.00
" D	10.00	50.00
" E	5.00	25.00

Group F.—Under this group is classified experimental work and researches covering subjects or appliances for which standard requirements are not adopted. The amount of the preliminary fee is $100 and bills are rendered monthly as the work proceeds.

Wherever approvals are granted, on the more common classes of devices, the names of the manufacturers thereof are placed in printed lists, distributed freely by the Underwriters' Laboratories, and in many classes the devices are labeled. Many of the leading organizations and authorities are at the present time using these lists or recognizing the labels as the basis of their recommendations or requirements.

Whenever approvals of appliances or materials are ready to issue, the favorable opinion, promulgated as above described, is followed up by one of three forms of supervision over goods marketed under the approvals.

RE-EXAMINATION SERVICE.—The oldest of these three forms is the *Re-Examination Service*, in which the maker is under contract to construct during the continuance of the approval, appliances in exact duplicate of the sample approved, and to pay certain fees annually (ranging usually from five to thirty dollars), with which the Laboratories partially defray the costs of obtaining samples in the open market or from the manufacturer and of making examinations and tests of the appliance one or more times yearly. Unsatisfactory features, if any are found as a result of the re-examination, are corrected by the maker on subsequent products.

INSPECTION SERVICE.—The second form of supervision is the *Inspection Service*, which is regarded by the Laboratories' management as superior to the Re-Examination Service and is applied so far as possible wherever the Label Service, later described, is not considered practicable. The Inspection Service includes regular and frequent examinations and tests of products at factories by Laboratories' engineer and the correction by the manufacturer of features found not in compliance with the standards of efficiency shown by the samples originally approved, together with supplementary examinations at the Laboratories of samples purchased in the open market or received from inspectors and users, thus affording counter-checks on the factory inspection work and determinations of the service value of the product.

The cost of the inspection service is billed monthly in each case to manufacturers co-operating.

THE LABEL SERVICE.—The third form of supervision by the Laboratories is the Label Service. This is regarded by the Laboratories' management as the most efficient and satisfactory of the three methods and is being utilized to a greater extent each year. The Label Service consists of inspections of devices and materials at the factories by Laboratories' engineers and the labeling of standard goods by stamps, transfers or metal labels, whereby they may be recognized wherever found; and in addition of systematic supplementary examinations and tests at the Laboratories of samples of labeled goods purchased in the open market or received from inspectors and users, and serving to counter-check the efficiency of the factory inspection work and to determine the service value of the product.

For a number of industries this service now includes inspection of the product at factories, check tests on materials purchased in the open market, service value determinations by retests of samples which have been in practical use, and schedule estimates showing comparative demerits noted on products. These elaborations are working to the decided advantage of all concerned, and are all possible only under the labelling system.

Experience has shown that this method is in every way superior for the purpose of bringing to the consumer the article he desires, for the purpose of placing competition between manufacturers beyond the point where deterioration in the quality of the output is made necessary, and for the proper protection of the Laboratories and the organizations co-operating with them which are given substantial recognition to efficient fire protection appliances.

It is also shown that an inspection and checking system of this nature can be efficiently operated under the Laboratories' direction without calling upon the manufacturer to give undue publicity to his manufacturing process or subjecting him to any embarrassment or annoyance.

The cost of this service is defrayed by charges made for the labels. These charges vary according to the nature and extent of the inspection needed. For goods which can be tested by machinery or which are machine made and run through factories in such quantities that tests of a number of samples of each day's output give a fair criterion of the whole product, the charges run from fifty cents ($0.50) to one dollar and a half ($1.50) per thousand (1,000) labels. For goods made by hand and goods which require inspection or test of each individual item, the charges run from seven and one-half cents ($0.07½) to fifty cents ($0.50) per label. In no case is the cost of the service as represented by the charge for the label sufficient to become a factor of importance in determining the selling price of the article labeled.

To the date of issue of this book the Underwriters' Laboratories had listed one or more appliances covered by the following index:

FIRE APPLIANCES

FIRE EXTINGUISHING APPARATUS:

Automatic Sprinkler Equipment, alarm valves, automatic sprinklers, dry pipe valves, guards, hangers, unions.
(For Sprinkler Supervisory Devices, see Signaling Apparatus.)
Chemical Extinguishers, 100, 33, 2½ and 1½ gallons, 1 quart, and for oil storage.
Fire Pails.
Gate Valves.
Hand Extinguishers, pail type, pails in tanks.
Hose, rubber lined. For public or private fire department. For chemical extinguishers on wheels. For hand chemicals. Unlined linen.
Hose House Padlocks, Hose Racks, Hydrants.
Play Pipe, Pumps, Pump Governor.
Steamer Connection Cap.

FIRE RETARDANTS:

- Fire Doors:
  - Fire doors for openings in fire walls.
    - Tin clad.
    - Sheet metal—sliding and swinging patterns.
    - Composite—sliding and swinging patterns.
    - Hollow metal—swinging pattern.
    - Steel—rolling pattern.
  - Fire doors for openings in vertical shaft.
    - Hollow metal—swinging pattern.
    - Metal clad—swinging pattern.
    - Composite—swinging pattern.
    - Steel—rolling, counterbalanced patterns.
    - Tin clad—counterbalanced, swinging and sliding patterns.
  - Fire doors for openings in corridor and room partitions.
  - Fire doors for openings to exterior fire escapes.
- Fire Shutters for openings in exterior walls.
- Frames for fire doors and shutters.
- Fire Door and Shutter Hardware.
  - Door checks.
  - Sliding type.
  - Swinging type.
  - Three-point locking mechanisms.
- Fire Window Frames.
  - Hollow metal type.
  - Solid section type.
  - Metal clad type.
  - Wired glass.
    - Putty.

- Fire Window Hardware.
  - Sash locks.
  - Sash chains.
- Gypsum Blocks.
- Paints, Fire Retardant.
  - Dry powder and liquid types.
- Partitions.
- Roof Coverings.
  - Built up type.
  - Prepared type.
  - Shingle type.
- Shop and Office Furnishings.
  - Cabinets, insulated.
  - Driers.
  - Safes—light weight.
  - Shelving, bins, boxes and box trucks, portable racks.
  - Waste cans.
- Miscellaneous Fire Retardants.
  - Automatic closers.
  - Fire shields for belt openings in floors and walls.
  - Fusible links.
  - Heat insulating coverings.
  - Lumber.
  - Plaster boards.
  - Post cap and girder supports.
  - Wall hanger.

SIGNALING APPARATUS:

- Battery Sets.
- Bells—see list of electrical fittings.
- Signaling Systems, fire alarms, thermostats.
- Local Manual Fire Alarm Boxes.
- Sprinkler Supervisory Devices.
- Watchmen's Time Recording Apparatus, boxes for central stations, local or private system apparatus, portable recorders and key boxes, stationary recorders, magnetos.

GAS, OIL, MECHANICAL AND CHEMICAL APPLIANCES

ACETYLENE APPLIANCES:

- Generators: For lighting; for welding and cutting.
  - Blow pipes.
- High Pressure Cylinders for lighting and welding.
- Lamps; Torches: Reducing and regulating valves.

ALCOHOL APPLIANCES: Flat Iron; Lamp.

BALING PRESSES.

CANS:

- Safety.
- Waste.

CAR-HEATING SYSTEM.

CELLULOSE ACETATE PLASTIC.

CLEANING LIQUIDS.

CONTAINERS FOR HAZARDOUS LIQUIDS, STORAGE AND SUPPLY SYSTEMS:
- Discharge Devices, hand operated, outside.
- Discharge Devices, hand operated, inside.
- Discharge Devices, power operated, inside.
- Safety Cans.
- Tanks.
  - Underground storage.
  - Stationary, for use in buildings.
  - Portable.
  - Shipping containers.
  - Miscellaneous tanks, cleaning and dip.
- Fittings for Hazardous Liquids.
  - Couplings, gauges, meters, unions, valves.

DUST CLOTHS.
FERTILIZER.
FILMS.
FIRE WORKS.
FLOOR BRUSH.
FLOOR OILS.
FUEL KINDLER.
FUEL FOR GASOLINE ENGINES.
FUEL-OIL APPLIANCES:
- Engines Auxiliary Tank (for Engines), Oil-burning Equipment, Shut-off and Drain Valves, Vent for Oil Tank.

FUMIGATORS.
GAS APPLIANCES:
- Engines, Heaters, Mixers, Producers, Regulators, Shut-off Valves, Fittings for Shut-off Valves—Pull Boxes, Roller Elbows.

GASOLINE APPLIANCES:
- Engines, Stationary and Portable.
- Gas Machines, Lighting Systems, Vapor Lamps.
- Gauges (see Fittings for Hazardous Liquids).
- Hose.
- Pumps (see Discharge Devices).
- Stoves.
- Strainers.
- Valves (see Fittings for Hazardous Liquids).

INCUBATORS, BROODERS AND DRINKING FOUNTAINS:
- Incubators.
- Brooders.
- Drinking Fountains.

KEROSENE APPLIANCES:
- Engines, Kilns, Oil Pressure Systems.

LANTERNS—WATCHMEN'S—Electric, Kerosene.
LIQUIFIED GAS APPARATUS.
MATCHES.
METAL POLISH.
PITCHING PLANT.
SLAKED LIME.
SOLDERING FLUX.
SWEEPING COMPOUNDS.
TRICHLORETHYLENE AND TETRACHLORETHANE.
TURPENTINE SUBSTITUTES.
WASTE CANS.

ELECTRICAL

FITTINGS, WIRE AND APPLIANCES OF ALL KINDS.

HINTS TO THE INSURED

Below will be found a number of hints which may prove useful in the avoidance of fire loss or in securing indemnification therefor.

If you hold a policy of a company which is not regularly licensed to do business in your State, read it carefully—it may differ vitally from the ordinary standard policy.

Certain things are specifically permitted by standard policies; others are strictly prohibited. When in doubt cousult the Policy.

If the insured cancels his policy, the company retains the usual short time rate; if the company cancels, it only retains a proportionate part of the premium. The company must give five days' notice of cancellation.

Under certain restrictions kerosene oil may be used and kept for sale. See policy and "special clauses."

Certain classes of property are especially excluded from insurance unless written in the policy or form. Among these are currency, deeds, securities, pictures, etc.

Encumbrances, changes in ownership, other insurance without permission, and various other circumstances may void policy. Be sure you have complied fully with its requirements.

Loss of rent or income by reason of fire may be insured against, but is not covered by the standard policy.

If you sustain a fire loss give immediate written notice to the companies interested, stating in round figures your estimate of the damage.

The property owner must use all reasonable effort to save and preserve his insured property in event of fire.

Keep an account of all expenses incurred in caring for saved property, for later consideration.

The insurance company will not take care of, nor take possession of, your premises, or of your saved property. Any loss caused by the insured's negligence to protect and care for his property at and after a fire is not covered by the insurance contract.

All the value of the property saved belongs to the insured, and all of the loss and loss expenses thereon up to the face of the policy belongs to the insurance.

After a fire it is the owner's duty to separate the damaged from the undamaged property, and to make an inventory showing quantity and cost of each article, with the amount of damage claimed thereon.

As the policy of an insolvent company would be held to contribute proportionately in any loss, it is advisable to cancel such policy as soon as the insolvency of the company is known.

Care should be used to have all policies read alike when covering the same property.

Large floor areas are discriminated against unless divided by acceptable fire walls, with openings properly protected.

Rate reductions are made for approved fire doors and shutters.

Engines should, if possible, be located in separate brick or stone building at some distance from factory.

The installation of automatic sprinkler systems is encouraged by liberal concessions in premium rates.

Fair allowances are made by underwriters to induce the use of such devices as watchmen's clocks, chemical extinguishers, fire pails, hydrants and hose, wired glass windows, etc.

Stairways should be built outside of main building in brick addition, cut off at each floor by fire door. If inside of building they should be enclosed and cut off by doors at each floor; but the spaces under stairways should be left entirely open.

Before adopting for use in your factory or store any new device or material, inquire of your local insurance agent whether its use is approved by insurance companies; otherwise you may learn that your insurance has been vitiated.

Use metal ash cans, and keep rags and oily waste in metal cans. The latter should be kept out of doors at night.

Be exceedingly cautious with matches. Keep them in metal or other fireproof boxes.

Make it *one* man's duty to inspect thoroughly and regularly all apparatus designed to prevent or extinguish fire or to send in an alarm; also to see that the premises are kept clean and free from anything which might feed a fire. Water casks and pails should be kept filled, sprinklers and valves in working order, gas jets properly protected, stoves and stovepipes in safe condition, etc.

By having your boilers insured against damage by explosion you can secure their regular inspection.

Be especially careful in filling and trimming oil stoves and lamps. Do it only by daylight.

Steam pipes should be covered with a suitable non-conducting material. They have been known to cause fires when in contact with or too near woodwork.

Every large establishment should have a well-organized and effective private fire department, fully equipped with good apparatus.

The division of buildings into fire sections by brick walls running up through and above the roof and cutting off cornices, with all openings protected by automatic fire doors is highly approved by underwriters. This arrangement tends to localize any fire which may occur.

All openings through walls and floors, such as doors, hatchways and belt-holes, may be protected by automatically closing doors and shutters, which are of great assistance, in event of fire occurring, in preventing its spread through the building.

Every factory of any size should be provided with a fireproof oil room, for the storage of illuminating and lubricating oils, etc. This can be constructed within the main building, if necessary, in such a manner as to materially lessen the fire risk inherent in such materials.

It is a good plan, when a plant is equipped with a dry-pipe automatic sprinkler system, and is located in a district subject to severe weather in winter, to protect the dry-pipe valves by placing them in insulated closets.

Where there is danger of an oil fire, keep pails of sand at hand. Water would help spread such a fire, while sand would quench it.

Skylights should be made of wired glass or protected from breakage by wire screens.

Floor beams should rest on ledges or in box anchors, in order that, should the floors fall during a fire, they would not pull down the outside walls.

Asbestos and other fireproof materials are now prepared in every conceivable way; so that an almost certain protection can be secured against any particular hazard.

Fireproof roofing materials are now plentiful, and should be used wherever feasible.

Beware of concealed spaces in interior woodwork. Wherever they are necessary, they should contain frequent fire stops; otherwise fire may be carried through them with great rapidity.

Walls and ceilings should be built of non-inflammable materials, the use of wood or wooden lath and plaster being discouraged by insurance men.

All windows through which fire could be communicated from an adjoining building or from another wing of the same building should be protected by automatic fire shutters.

All fire doors and shutters should be closed nights, Sundays and holidays, or whenever the building is not occupied.

It is advisable to protect openings between important divisions of a building with a fire door on each side of the wall.

Constant care must be exercised to keep all protective appliances and apparatus in good order. Dependence upon deteriorated protective devices is more dangerous than is their entire absence.

An equipment of open sprinklers on the exterior of the building is very desirable in the case of a wooden building which is exposed by another building. These should be arranged under the cornice and over each window. In some cases every window should be protected by a sprinkler.

Do not let your sprinkler equipment freeze up in winter. It may burst and inflict water damage, or it may be frozen up and ineffective when a fire occurs.

Sprinkler protection, to be effective, must be thorough. Every nook and corner must be protected or a fire may have time to grow beyond control.

Gas jets are dangerous unless surrounded by wire guards.

Every sizable factory should have, in connection with its private fire department, one or more hose houses, each sheltering a hydrant, with hose already attached and neatly laid out ready for instant use, together with axes and other necessary tools. Permanent ladders should be erected at points where they might be needed in fighting a fire.

Be certain that your supply of water for sprinklers and hydrants is always sufficient and easily obtainable.

Fire pumps should be located beyond reach of fire, and should be constantly in condition for immediate and protracted use at their full capacity. The "Underwriter" pattern is deemed the best style of fire pump.

A tank used to supply water to a sprinkler system should not be used for domestic purposes, as sediment is apt to accumulate and clog sprinkler pipes.

A steam coil or an open live steam pipe should be used to prevent water in tank from freezing. There should be a permanent ladder leading to gravity tank.

Heavy pressure of water, satisfactory to underwriters, may be obtained from public water works systems, private reservoirs or standpipes, air pressure tanks or automatic steam pumps.

No large mercantile or manufacturing establishment can be considered properly equipped which has no automatic fire alarm system. There are a variety of these, and they can be arranged to suit every requirement. Some of them are combined with automatic sprinklers.

Use none but frost-proof hydrants where the winters are cold enough to freeze up ordinary hydrants.

The underwriters have adopted a standard for fire hose; see that your hose is up to standard and in good condition.

Great care should be exercised in the treatment of hose. It should be kept in a well-ventilated house, and should be emptied and carefully laid out on shelves after using.

It will be found economical in the end to purchase thoroughly good hose, even though the price is somewhat higher than other hose said to be "just as good."

Probably more fires have been put out by means of water pails than by any other instrumentality. A liberal supply of pails, well scattered throughout the premises and kept constantly filled, provides an excellent safeguard against fire.

Watchmen are proverbially sleepy; hence the desirability, if not the absolute necessity, for the use of watchmen's clocks and watches, to secure regular and systematic inspection of the premises during nights, Sundays and holidays.

A good system for conveying an alarm of fire to employees, and especially to the members of the private fire department, should be devised by the factory owner. Promptness may mean the safety of your property, when delay would cause its loss.

A generous supply of hand fire extinguishers will contribute much toward the safety of your premises.

Fire prevention is better than fire insurance for a reputable house. Insurance companies may indemnify you fully for direct loss, but they will not and cannot make good the loss occasioned by the stoppage of your business, such as loss of old customers and old and skilled employees.

Hand grenades are particularly adapted for use in some lines of business, and in special locations—possibly they would suit your needs.

A supply of efficient fire escapes may be the means of saving many lives. A life saving net is an excellent addition to the factory apparatus.

None but approved safety lanterns should be used by watchmen and others in a factory, especially in one containing inflammable goods.

Concerns still clinging to the use of sawdust in cuspidors should substitute sand.

Be careful in your choice of executive men for your private fire department. Have those only in power whose authority will be recognized, who are cool and ready in emergencies, and who live near the establishment.

If you use, or intend using, acetylene gas, make certain that your generator is of a type approved by underwriters, that it is properly situated, and that you are violating no rule concerning storage of calcium carbide.

Bear in mind that, while acetylene gas, under certain conditions, is as safe as ordinary illuminating gas, under certain other conditions it has highly explosive qualities. Be sure you are right—then go ahead.

It has been aptly remarked that "a pail of water at the beginning will extinguish any fire, provided the pail of water is there, and some one to use it." Also that a sprinkler "is itself the first pail, but it requires no human agency to operate it. It is on duty night and day."

Rubbish, if permitted to accumulate, is extremely likely to some day cause a fire. This is especially true if oily rags, cotton or sawdust form a part of the accumulation, for then spontaneous combustion is apt to occur, and another mysterious fire, with no imaginable cause, is reported.

Stoves and stove pipes have caused many fires. Pipes should always be securely fastened, particularly when passing through walls or partitions; and the sheet of tin or zinc placed under the stove should project for a considerable distance in front of it, to prevent damage by live coals.

Do not permit any joists to run into the mason work of a chimney as the chimney, in settling, is apt to crack in such a way that the wood will be exposed to the action of the fire. Watch chimneys closely and remedy defects promptly.

If your building is heated by a hot-air furnace, see that ample space (at least one foot) is left between the furnace, smoke pipe and heat pipes, and the joists above them. Better further protect the joists by a fireproof covering.

With the increasing use of electricity for light and power, the number of fires attributable to stray electricity is growing. Elaborate rules have been promulgated by organized underwriters, electricians and architects to ensure the safe installation of electrical plants; but the actual safety depends very largely upon the honesty and conscientiousness of the local electrician who does the work. Most of his work is covered up so that it is almost impossible to detect existent defects.

Use sand for the absorption of oil drippings, not sawdust.

Never deposit ashes in a wooden receptacle.

There are several preparations for rendering fabrics practically fireproof. If you have gas jets in proximity to curtains, have the latter fireproofed.

Mansard and shingled roofs, wooden awnings, blind attics, etc., do not find favor with underwriters.

Use only a good quality of bricks and mortar in the construction of chimneys.

The use of kerosene on floors when sweeping, or of sawdust on floors, adds to the fire hazard and the insurance premium.

Holiday decorations in stores in which lights and flimsy fabrics are utilized, constitute a positive fire risk.

Keeping merchandise in tin-covered boxes, or on skids or platforms raised above the floor, or on the grade floor of building, all tend to reduce the liability to damage by fire or water.

Co-insurance may be briefly defined as the carrying or insuring of a portion of his risk by the owner in case his insurance in companies falls below a certain fixed percentage of the value of his insured property. A concession in premium rate is usually granted for a high percentage of co-insurance clause.

Keeping goods in fireproof safes reduces risk and premium.

Remember that heat has a great expansive effect on iron pillars and beams, which should be thoroughly protected by some non-conducting material.

Put in cut-offs or fire-stops at every floor of your building and wherever feasible, so that fire will not have free play through the interior of partitions.

Wrought iron is much more affected by the attack of rust than is cast iron. A covering of lime mortar tends to prevent deterioration of iron by rust.

When installing a sprinkler system, be thorough; protect every portion of your plant, placing sprinklers under large shelves, platforms, racks, etc., where the water distributed by the ceiling heads might not reach and quench a fire.

Keep the valves in sprinkler supply pipes always open.

Explosives must not be used or stored, except under prescribed conditions or by special permission.

If your property is mortgaged, be certain that you have complied with policy requirements respecting mortgaged property.

Permission of the insurance companies is necessary before making extensive repairs or alterations. Read the policy in this connection.

If insurance is carried in more than one company, be sure that permission for other insurance is given in each policy.

Losses are adjusted according to the present value of the goods damaged or destroyed.

To extinguish a chimney fire, close the doors and windows of the room from which the flue leads, in order to prevent draught, and then sprinkle a cup or two of salt on the fire.

If a building is to be vacant or unoccupied longer than ten days, obtain permission from the insurance companies.

A factory may be run until 10 P. M., or closed for not exceeding ten days, without special permission.

HAZARDS

GENERAL INFORMATION RELATING TO EXPLOSIVES AND OTHER DANGEROUS ARTICLES*

EXPLOSIVES

An explosive consists of a substance capable of conversion with great rapidity into gaseous form with evolution of heat. The volume of gas given off is many times that of the volume of the explosive. The effective work of commercial explosives is due to the large amount of gas and heat given off and to the rapidity with which the chemical action occurs.

Practically all explosions are in reality a burning of the explosive material. The difference between the burning or explosion of an explosive and the burning of wood, coal or other inflammable material is that in the former case the oxygen necessary for the burning is furnished from one of the components of the explosive, while in the latter case the necessary oxygen is furnished by the air.

In the firing of explosives other than high explosives the action is communicated by actual contact of the flame passing from one part of the charge to the other. These explosives are ignited by a powder fuse in mining or by a primer in rifle and shotgun cartridges. In the explosion of a high explosive the action through the material is transmitted as a wave motion, much in the same manner that sound vibrations pass through the air. Such an explosion is also characterized by the term detonation, and is many times quicker than the ordinary explosion of such materials as black powder. High explosives can be exploded by heat, shock, friction, or by use of a blasting cap. It is this last means that is employed whenever high explosives are used in practical work. In fact, a high explosive may be best defined and distinguished as one that may be detonated by means of a blasting cap.

Black Powder is the oldest and most widely known explosive material. Black powder is not a high explosive. Black blasting powder is a mixture of sulphur, charcoal and sodium nitrate. Black rifle powder is a mixture of sulphur, charcoal and potassium nitrate. Sodium nitrate is used in blasting powder in the United States on account of its lower cost, and in spite of the fact that it has the property of absorbing moisture from the air. Potassium nitrate does not have this property, and hence the black rifle powder has better keeping qualities than the blasting powder. However, any deterioration of a black powder from absorption of moisture renders it less easy to ignite, and consequently less dangerous. At the same time, its value as an explosive is lessened or destroyed.

In the manufacture of blasting powder the sodium nitrate is dried and pulverized, and the charcoal and sulphur are also pulverized. The three ingredients are then placed in their proper proportions in a wheel mill in which the mixing takes place, and the materials are at the same time reduced to a very fine powder.

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* Issued by the Bureau of Explosives of the American Railway Association,

After the mixing is completed the material is removed to a press mill, where it is pressed by hydraulic pressure into hard cakes. This cake is then broken up and formed into grains in the corning mill. The granular powder is then glazed by placing it in a rotating cylinder with powdered graphite. The glazing renders the grains less angular and gives them a polished surface. The glazing process is omitted entirely with some grades of blasting powder. The powder, after glazing and drying, is packed for shipment and the usual container is the 25-lb. metal can. Black rifle powder is made in much the same manner as above, with the exception that potassium nitrate is used instead of sodium nitrate.

Black powder is very insensitive to shock or friction, and for all practical purposes it may be said that it cannot be exploded in this way. If, however, a spark is produced in any manner the powder is readily ignited. The finer the grains the easier the powder may be ignited. It is the peculiar susceptibility to sparks which renders the transportation of black powder hazardous. The term low explosives may be used for black powder or other explosives of similar composition.

SMOKELESS POWDERS usually consist principally of nitrocellulose. The chief risk attending transportation of these powders is one of fire from external causes.

Smokeless powder for cannon would increase the intensity of the fire, but it must be strongly confined, as in a cannon, to make it explode. On account of the finer granulation, smokeless powder for small arms would burn much more rapidly.

Some few so-called smokeless powders are made from chlorate mixtures and are, of course, subject to the same risks as high explosives.

DYNAMITE may be defined as any material formed by the mechanical mixing, of nitroglycerin with an absorbent. Nitroglycerin is formed by the treatment of glycerin with a mixture of sulphuric and nitric acids. After formation of the nitroglycerin in this way it is separated from the mixed acids and thoroughly washed with water till all traces of acid are removed. The nitroglycerin is a heavy, oily liquid, having somewhat the consistency of glycerin, and having generally a yellowish color. Nitroglycerin of itself is extremely sensitive to shock, friction or detonation, and is too dangerous for railway transportation. About the only use for it in a liquid state is in blowing oil wells. For this purpose it is customary to transport it by wagon. Many accidents have occurred in this way.

In making dynamite, nitroglycerin is mixed with an absorbent or "dope." In this country the usual practice is to use a mixture of sodium nitrate and wood pulp for a dope for a straight dynamite. In making ammonia dynamite the dope usually consists of a mixture of ammonium nitrate, sodium nitrate, wood pulp and sulphur. It is also required that an antacid of some kind be used in all dynamites to neutralize any traces of acidity accidentally remaining in the nitroglycerin. The materials most often used as antacid are magnesium carbonate or calcium carbonate. Chalk or limestone is composed chiefly of calcium carbonate.

The ingredients of the "dope" should be thoroughly dried before mixing, and the dope should be of such quality that it will absorb and hold the nitroglycerin added. As wood pulp is much more efficient as an absorbent than sodium nitrate, the high grade dynamites must have much more pulp than the low grades. After the nitroglycerin has been thoroughly mixed with the absorbent either mechanically or by hand, it is taken to the packing-house, where it is loaded in paper cartridges. These cartridges are made of stout paper, and are dipped in melted paraffin before loading. It is the usual practice after filling cartridges with ammonia dynamite to dip them again into melted paraffin.

In making gelatin dynamite the nitroglycerin is first mixed with soluble nitrated cotton, thus forming a jelly-like mass; afterwards a dope somewhat similar to that for straight dynamite is thoroughly mixed with the jelly-like mass, thus forming a gelatin dynamite. Gelatin dynamite, when properly made, is less liable to leak than straight dynamite.

Gelatin, or blasting gelatin, differs from gelatin dynamite in that it contains no absorbent dope.

The sodium nitrate and wood pulp used in dynamite have the power of absorbing moisture from the air, and are therefore said to be hygroscopic. Ammonium nitrate, which is used in ammonia dynamites, is much more hygroscopic than the sodium nitrate or the wood pulp. The use of paraffined paper for the cartridges tends to prevent the absorption of moisture from the atmosphere and the leakage of nitroglycerin from the cartridges. The double coating of the ammonia dynamite cartridges is done on account of greater hygroscopic qualities.

A dynamite made up with a proper absorbent in sufficient quantity will not leak when manufactured, but if subjected to long storage it has a tendency to gradually absorb moisture from the atmosphere This absorption naturally takes places faster if the dynamite is stored in a damp magazine. As a result of this absorption of moisture, the power of the dope to hold the nitroglycerin is lessened, and the cartridge becomes stained with nitroglycerin; these stains are in turn transmitted to the box and to the floor of the magazine. Ammonia dynamites, having a greater power of absorbing moisture than the others, deteriorate sooner in this way.

Dynamite is exploded by shock, friction or detonation. When burned in large masses it usually explodes, but it can be burned with comparative safety in small quantities when entirely unconfined. Dynamite when cooled to a temperature of about 45° F. entirely loses its ordinary soft and plastic condition and becomes entirely solid and hard. In this condition it is said to be frozen completely. Frozen dynamite is less sensitive to shock and friction than when in the soft condition, but partially thawed dynamite is said to be more sensitive. It is necessary to "thaw out" frozen dynamite to get complete detonation in practical use. The thawing should always be done in an apparatus well adapted to the purpose. It must, however, be remembered that even frozen dynamite is liable to explode if carelessly handled.

Many "low freezing" dynamites are now made by the addition of nitrotoluol or other suitable ingredients to the nitroglycerin. With the exception of the ingredient added to the nitroglycerin to lower the freezing point, these dynamites are similar in composition to ordinary dynamites. Their use in cold weather avoids the inconvenience of thawing. In other respects they involve much the same hazards in handling and in transportation as do the ordinary dynamites.

High explosives other than dynamite generally come under four groups: I. Nitrocellulose and Nitrostarch Explosives; II. Chlorate Mixtures; III. Ammonium Nitrate Mixtures; IV. Picric Acid and Picrates.

NITROCELLULOSE AND NITROSTARCH EXPLOSIVES.—The basis of these explosives is either nitrostarch or nitrocellulose. These compounds are formed by the treatment of either starch, cotton, paper, or wood meal, with a mixture of nitric and sulphuric acids. The acid is then removed by thorough washing with water, and often by boiling with water. The resulting nitrostarch or nitrocellulose has the same appearance as the material before nitration. It has, however, become much more inflammable, and under

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certain conditions explosive. For use as a commercial explosive, the nitrostarch or nitrocellulose is usually mixed with sodium nitrate or a mixture of sodium and ammonium nitrates. Explosives of this group are generally less sensitive to shock, friction and detonation than dynamites. Having no liquid ingredient, they are not subject to exudation. In use, they are exploded by the ordinary blasting cap or electric blasting cap. As a rule, explosives of this group burn with great rapidity when ignited in the open air.

CHLORATE MIXTURES.—Explosives of this group consist of a mixture of chlorates or perchlorates or both with some organic matter. Explosives containing chlorates are liable to be sensitive to shock, friction or detonation. Some of them ignite at low temperatures. Chlorate explosives if made from improper or impure ingredients, are liable to spontaneous ignition. Increase of sensitiveness is also possible.

Explosives containing perchlorates without chlorates, are less sensitive to impact, friction and detonation than the chlorate explosives and are not liable to spontaneous decomposition.

AMMONIUM NITRATE MIXTURES.—Explosives of this group consist of a mixture of ammonium nitrate with some organic combustible material. As a rule, these explosives are the safest explosives. They are less sensitive to shock, friction and detonation than the others. Owing to a large percentage of ammonium nitrate, some of these explosives will burn very slowly even when placed in a hot fire.

PICRIC ACID AND PICRATES.—Picric acid consists of a yellow crystalline powder of intensely bitter taste and explosive properties. It is formed by the nitration of phenol (carbolic acid). Picric acid combines directly with metals to form salts known as picrates. Picric acid and picrates are used in the color industries and in the manufacture of explosives, principally for military use. High price and fumes from explosion render them of little use for commercial explosives.

EDITOR'S NOTE.—For handling and storage of Explosives, see page 211.

DANGEROUS ARTICLES OTHER THAN EXPLOSIVES

For the purposes of safe transportation by rail, dangerous articles other than explosives are divided into five classes, namely:

I.—Inflammable Liquids. (Red label.)
II.—Inflammable Solids. (Yellow label.)
III.—Oxidizing Materials. (Yellow label.)
IV.—Corrosive Liquids. (White label.)
V.—Compressed Gases. (Red or green (gas) label.)

An inflammable liquid, as defined by the Bureau of Explosives, does not mean any liquid that can be burned. The meaning is restricted to liquids which at ordinary temperatures, give off inflammable vapors. These vapors are not only inflammable, but, when mixed in proper proportions with air in an enclosed space, will explode with violence, if ignited by any means. This action is exactly similar to explosions caused by ignition of mixtures of coal gas and tar in houses, cellars, sewers, etc., which frequently occur through the accidental escape of gas into enclosed spaces. Any liquid giving a flash point of 80° F. or less, open cup, is classified as an inflammable liquid.

The flash point* is determined by gradually heating the liquid in question in a small open cup. After each five degrees rise in temperature a small flame is passed across the top of the cup about one-quarter of an inch above the surface of the liquid. The lowest temperature at which a flash passes over the surface of the liquid is called the flash point. It will readily be seen that the lower the flash point of any liquid the greater the risk of handling.

Inflammable solids include such solid materials other than explosives as are liable to cause fires by self-ignition though friction, through absorption of moisture or through spontaneous chemical changes.

Oxidizing materials† include all substances, such as chlorates, peroxides, perchlorates, permanganates and nitrates, that yield oxygen readily to stimulate combustion of organic matter.

Corrosive liquids include the strong mineral acids, in strength greater than ½ concentrated, and other strongly corrosive liquids, the transportation of which involves risks, similar to transportation of the acids.

Compressed Gases.—Gases are commonly shipped compressed in steel cylinders. Among the inflammable gases so shipped are acetylene, blaugas, hydrogen gas, pintsch gas, liquefied petroleum gas and coal gas; among the non-inflammable gases shipped are anhydrous ammonia, carbonic acid gas or carbon dioxide, chlorine, compressed air, nitrous oxide or dental gas, oxygen and sulphur dioxide. These gases are compressed or liquefied at pressures varying from 50 to 1,800 pounds per square inch or higher. Of the above gases the following are commonly shipped in the liquefied condition,—blaugas, liquefied petroleum gas, anhydrous ammonia, carbon dioxide, chlorine, nitrous oxide, and sulphur dioxide. The inflammable gases are liable to be ignited if they escape, while any compressed gas may burst the cylinder from internal pressure. Pressure will always increase with increase of temperature, and should any cylinder of compressed gas be exposed to fire it will inevitably explode unless provided with an efficient safety device. Cylinders occasionally explode on account of being dropped or exposed to external violence.

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* See also page 216.
† See also page 130.

Definitions

A brief description of the principal articles included in the above classes, and other articles of special or peculiar hazard for rail or water transportation, is given below:

Acetate of Amyl is a clear, colorless liquid having an odor like bananas. It is made from amyl alcohol and is used as a solvent of nitrocellulose in the manufacture of lacquers. Different grades of amyl acetate vary in inflammability with the character of impurities contained. The commercial grades in ordinary use give a flash point about 70° F., and are therefore classed as inflammable liquids. Very small units of the absolutely pure material give flash point above 80° F., and are not classed as inflammable liquids.

Acetate of Ethyl or Acetic Ether, is a clear, colorless volatile liquid of fragrant odor, used as a medicine and as a flavoring. It is very inflammable, having a flash point of approximately 40° F. It is classed as an inflammable liquid.

Acetate of Methyl is a clear colorless liquid of pleasant odor. It is of about the same degree of inflammability as acetone, and is classed as an inflammable liquid under the I. C. C. Regulations and is not accepted by many of the steamship companies.

Acetic Ether. (See Acetate of Ethyl.)

Acetone is a clear, colorless liquid, having a pleasant odor somewhat similar to wood alcohol. It is used largely as a solvent for nitrocellulose in the production of lacquers, etc. Acetone is highly inflammable, having a flash test of 35° F. It is classed as an inflammable liquid.

Acetylene is an inflammable gas of formula $C_2 H_2$. It is formed by the action of water on calcium carbide. When compressed alone it is liable to explosion. It is, however, extremely soluble in acetone. It can be shipped only in steel cylinders filled with a porous material satisfactory to the Bureau of Explosives. This porous material must be charged with acetone or equivalent solvent. Acetylene is used for head lights on locomotives, automobiles and motor boats, for signal lights, and for welding purposes. It requires a red (gas) label.

Acid, Acetic, is a clear, colorless liquid, having a pungent odor, and is used chiefly in technical work. It is not inflammable, nor is it classed as a corrosive liquid under the regulations. Glacial acetic acid is the most concentrated acetic acid, and solidifies at temperature of 50° F. Its shipment is restricted by the Department of Commerce.

Acid, Arsenic, is a white crystalline solid material, not inflammable or corrosive, but highly poisonous, and, therefore, prohibited by some steamship lines. It is also shipped in concentrated aqueous solution. Its shipment on passenger steamers is restricted by the Department of Commerce.

Acid, Arsenious, is a white, solid material, either in powder or lumps, used in paint, glass and leather industries; it is highly poisonous, but not otherwise dangerous. Its shipment on passenger steamers is restricted by the Department of Commerce.

Acid, Carbolic, is shipped both in the solid and liquid state. Material is poisonous, somewhat corrosive, and has an exceeding strong odor. It is not classed as an inflammable liquid or solid, but its shipment is restricted by the Department of Commerce.

Acid, Formic, is a colorless liquid of pungent, irritating odor. When concentrated, it has a caustic effect on the skin, but does not have the strong corrosive effect of the mineral acids, and is not classed as a corrosive liquid under the regulations. Its shipment is restricted by the Department of Commerce.

Acid, Hydrochloric (Muriatic Acid), is a corrosive liquid, varying from colorless to yellow, according to purity. It gives off acid vapor of a peculiarly irritating odor. It cannot be packed in iron drums, but is usually packed in glass bottles or carboys. It is also shipped in tank cars provided with acid-proof lining. Hydrochloric acid will damage or destroy many articles by contact, but does not cause fires. It is classed as a corrosive liquid.

Acid, Hydrocyanic, is a colorless, volatile liquid, having odor and taste of bitter almonds. Both liquid and its vapor are highly poisonous. It is of slight commercial importance. Its shipment by water is restricted by the Department of Commerce.

Acid, Hydrofluoric, or Etching Acid, is a fuming corrosive liquid used principally for etching on glass. It cannot be kept in glass bottles, owing to its solvent action on glass. It also dissolves all metals except gold, platinum and lead. It is consequently shipped in vessels of lead, rubber, or ceresine (a material similar to paraffin), or in asphaltum-lined barrels or wooden tank cars. Hydrofluoric acid is made by treatment of the mineral known as fluor spar with sulphuric acid. It is classed as a corrosive liquid. It is refused by many steamship companies.

Acid, Mixed, is a mixture of nitric and sulphuric acids, used for nitration of glycerin or cellulose in the manufacture of nitroglycerin and nitrocellulose. This acid mixture coming into contact with organic matter is sure to cause fire, and, therefore, should not be shipped or stored in glass containers, owing to risk of breakage, except it is in a glass carboy, packed in a tight cylindrical iron case, covering bottom and sides of carboy, the space between bottle and case being filled with non-combustible cushioning material, and the case fitting tightly in the outside wooden box. It is also shipped in iron drums or tank cars. It is classed as a corrosive liquid. It is refused by many steamship companies.

Acid, Nitrating. (See Acid, Mixed.)

Acid, Muriatic. (See Acid, Hydrochloric.)

Acid, Nitric, is a fuming, corrosive liquid, varying from colorless to red, according to purity. It has a corrosive action on almost all metals. It is also a strong oxidizing agent, and when brought into contact with wood or other organic matter is likely to cause fire. Nitric acid is made of different strengths for different purposes. The stronger acid is more likely to cause fire. It is packed in glass bottles or carboys. These bottles or carboys must be packed in incombustible packing. It is formed by the action of sulphuric acid on a nitrate—usually sodium nitrate. It is used largely in the manufacture of explosives. It is classed as a corrosive liquid. It is refused by many steamship companies.

Acid, Nitro-Hydrochloric, is a mixture of nitric and hydrochorlic acids. This acid gives off chlorine gas, especially if warmed. It is highly corrosive, having the power to dissolve all metals, including gold and platinum. It is packed in glass bottles or carboys. It is classed as a corrosive liquid.

Acid, Oxalic, is in the form of a white crystalline solid. It is odorless, and slightly corrosive but poisonous. It is not generally regarded as hazardous for transportation.

Acid, Phosphoric, consists of a clear colorless, odorless liquid of a syrupy consistency. It is but very slightly corrosive, and is not classed as a corrosive liquid by the I. C. C. Regulations, nor is it generally restricted by the steamship companies.

Acid, Picric, is a yellow crystalline solid of intensely bitter taste. It is used in leather and dye industries, also as a military explosive. The dry material is a high explosive. When thoroughly mixed with not less than 10 per cent water, in waterproof containers, it is treated as an inflammable solid.

Acid, Pyroligneous, is the crude acid obtained by the destructive distillation of wood. It is of yellowish or brownish color, and contains approximately 6 per cent acetic acid, together with tarry matters. It has a strong smoky odor. It is entirely uninflammable and without hazard in shipment.

Acid, Sulphuric, is a heavy, oily, corrosive, odorless liquid. It varies from colorless to almost black, according to purity. Sulphuric acid is made by the oxidation of sulphur, by burning the native sulphur or iron pyrites. The sulphur dioxide formed directly by the burning is still further oxidized to sulphuric acid by either the contact process or the lead chamber process. Sulphuric acid will char wood or almost any other organic matter, but is unlikely to cause fire. It is largely used in manufacture of chemicals, acids, fertilizers, explosives, and in refining of oil. It is shipped in glass bottles and carboys, or in iron drums or tank cars. It is classed as a corrosive liquid. It is refused by some steamship companies, and its shipment by boat is restricted by the Department of Commerce.

Acid, Valerianic, is a colorless, oily liquid of a very offensive, rancid odor. It is not dangerously corrosive or inflammable, but owing to offensive odor is not accepted by some steamship lines.

Air, Liquid, is air liquefied by high pressure and low temperature. It is shipped in double walled glass bottles with silvered walls; the space between the double walls is a vacuum. These containers are built on the same principle as the well-known "thermos bottles." The containers for liquid air are not tightly closed, and evaporation may take place without causing internal pressure. Liquid air, owing to its concentration has a strong oxidizing effect on finely divided organic matter. Owing to its extremely low temperature, it causes effects similar to severe burning if it should come in contact with the skin. It is of small practical value, and shipments are chiefly confined to material for demonstration purposes.

Alcohol, Denatured, consists of grain alcohol to which some substance has been added, rendering it unfit for use as a beverage, but not interfering with its use in the arts. Ordinary denatured alcohol contains wood alcohol and benzine, and consequently the flash point is lowered to 40° F., approximately. It is classed as an inflammable liquid.

Alcohol, Grain, is a clear, colorless liquid of characteristic taste and color. It is obtained by fermentation of grain or other starch or sugar-containing material. It mixes with water in all proportions. Pure alcohol has a flash test of 55° F. It is classed as an inflammable liquid.

Alcohol, Solidified, consists of wood alcohol which has been colloided to a soft semi-transparent mass of about the consistency of a jelly. It is made either by colloiding with nitrocellulose, or with a kind of soap. The former kind is unchanged by moderate heat while the latter is liquefied. Solidified alcohol gives off inflammable vapors at temperatures of approximately 50° F. or above, but owing to the fact that its physical condition is such as to prevent leakage from defective containers it is not classed as a dangerous article.

Alcohol, Wood, is a clear, colorless liquid, of a peculiar odor. It is obtained by the dry distillation of wood. It mixes with water in all proportions and has a flash test of 45° F. It is classed as an inflammable liquid.

Alfalfa Feeds consist of varying mixtures of ground alfalfa hay, with molasses, with or without the addition of cracked corn, oats, and various other feeds. Carload shipments of these feeds under some circumstances heat spontaneously and in extreme cases may cause fire. The use of inferior or mouldy, or exceedingly damp ingredients, or the wetting of the material in transit promotes this heating. It is not classed as a dangerous article.

Ammonia, Anhydrous, is a compressed liquefied gas shipped in iron or steel cylinders at pressure approximating 150 lbs. per square inch at 60° F. Gas is entirely non-combustible and is used for refrigerating purposes. Cylinders must be kept away from heat and must not be dropped or struck. It requires a green (gas) label.

Ammonia, Aqua, is in the form of a clear colorless liquid having a strong odor of ammonia. It consists of ammonia gas dissolved in water. It is slightly corrosive but has a strong odor. It is not classed as a hazardous article by the I. C. C. Regulations, but its shipment is restricted by some of the steamship companies.

Ammonium Hydroxide. (See Ammonia, Aqua.)

Ammonia Water. (See Ammonia, Aqua.)

Ammonium Picrate, is a crystalline powder of yellow to orange color and having an intensely bitter taste. It is a high explosive, but is extremely insensitive to friction, impact or detonation.

Ammunition Bombs or Bombardments are fireworks. They consist of heavy paper shells containing bursting charge of black powder or other explosive, and in addition usually contain colored stars of chlorate composition. These bombs are meant to be fired into air from a mortar. Some of these bombs are very large and heavy and explode with great violence. When assembled with blasting caps or detonators they are forbidden for transportation. These bombs are not accepted by steamship lines, and when shipped by rail are classed as special fireworks or as high explosives, according to nature and composition.

Ammunition for Cannon embraces all fixed or separate-loading ammunition too heavy for use in small arms. When the component parts are packed in separate outside package such packages may be shipped as smokeless powder for cannon, explosive projectiles, empty (including solid and sand loaded) projectiles, primers, or fuses. Igniters composed of black powder may be attached to packages in shipments of smokeless powder for cannon.

Ammunition for Small Arms consists usually of a paper or metallic shell, the primer, powder charge and projectile, the materials necessary for one firing being all in one piece, such as is used in sporting or fowling pieces, or in rifle, pistol practice, etc.

Amyl Acetate. (See Acetate of Amyl.)

Aqua Fortis. (See Acid, Nitric.)

Aqua Regia. (See Nitro-Hydrochloric Acid.)

Animal Charcoal or Bone Black consists of a charcoal formed by the destructive distillation of bones. It is used largely as a clarifying agent in sugar refining, etc. Owing to the large amount of mineral matter contained, it does not possess the hazards of wood charcoal, and is not classed as an inflammable solid. It is accepted generally by the steamship companies.

Arsenic Trioxide. (See Acid, Arsenious.)

Asphaltum Paint or Varnish consists of asphaltum in solution in benzine, benzol, or other solvents. Its inflammability depends on the nature of the solvents used.

Automobile Supplies, N. O. S., may include gasoline, acetylene gas tanks, or rubber cement, which are all properly classed as inflammable.

Bags, Empty, used for nitrate of soda. The jute bags used in shipment of nitrate of soda become impregnated with the nitrate, which, unless thoroughly removed by washing with water, renders the bags very inflammable.

Barium Chlorate. (See Chlorates.)

Barium Nitrate consists of a heavy white crystalline salt, which is a strong oxidizing agent. It is occasionally used in explosives, but mostly to produce a red color in fireworks. It is commonly shipped in barrels or boxes, and thus packed it is not classed as dangerous by the I. C. C. Regulations.

Barium Peroxide, Barium Dioxide, Barium Binoxide, is a heavy grayish white powder insoluble in water. It is a strong oxidizing agent used principally in bleaching and in the manufacture of hydrogen peroxide. It is incombustible alone, but when mixed with organic matter is dangerously inflammable. Mixtures of barium peroxide and organic matter are ignited by friction and barium peroxide rubbed between wooden surfaces is liable to cause fire. It is classed as an oxidizing material and must be shipped in metal containers, except small quantities which may be packed in bottles.

Barrels, Empty, having been previously filled with gasoline, benzine, naphtha, or other inflammable liquids should be shipped with bungs closed, as interiors contain inflammable vapor either alone or mixed with air in proportions to form explosive mixture. Accidental entrance or contact with spark or flame may cause fire and explosion. So-called "empty barrels" often still contain a small quantity of the inflammable liquid which may escape in handling the barrel, thus causing further risk. The risk is not considered great, however.

Batting, Dross, consists of an intimate mixture of cotton fiber and rosin. It is formed by the filtration of melted rosin through raw cotton. If ignited it burns very rapidly, but is not regarded as liable to spontaneous ignition. It is not classed as inflammable by the I. C. C. Regulations, but it is not accepted by steamship companies.

Benzene. (See Benzol.)

Benzine is the lighter and more inflammable distillate from crude petroleum. It is of varying specific gravity, but is exceedingly inflammable, and has a well-known characteristic odor. It is used for lighting, heating, power and as a solvent. The flash point varies with different grades, but is approximately 0° F. or below. It is classed as an inflammable liquid.

Benzol is a clear, colorless liquid of aromatic odor, distilled from coal tar. It is very inflammable, having a flash test of approximately 20° F. It is classed as an inflammable liquid.

Benzol, Trinitro, is a yellow crystalline solid. It is a high explosive.

Benzoyl Chloride, consists of a clear, colorless liquid, having an intensely irritating and offensive odor. It is combustible, but not dangerously inflammable. It is not classed as an inflammable liquid by the I. C. C. Regulations, but is refused by many of the steamship companies.

Bichloride of Tin (or more properly Tetrachloride of Tin) is shipped in two forms. In the anhydrous condition it is in the form of a heavy, colorless, corrosive liquid, giving off fumes on exposure to the air. It is shipped in bottles, carboys and in iron drums, and is classed as a corrosive liquid. It is also shipped in a hydrated condition, in the form of white crystals. In this form it is not classed as a hazardous article for transportation.

Bichromate of Soda and Bichromate of Potash are yellow crystalline salts which act as oxidizing agents. They are not considered hazardous for railroad transportation, and are accepted by all steamship companies so far as known.

Binitro Toluol is a yellow crystalline solid, melting at 158° F. Material is not explosive nor dangerously inflammable. In appearance it strongly resembles trinitrotoluol, which is a high explosive.

Blacking, N. O. S. Some liquid blackings contain a volatile inflammable liquid solvent, and may therefore give a flash test of 80° F. or below, in which case they will be classed as inflammable liquids.

Blacking, Stove, Liquid. (Similar to above.)

Blasting Caps consist of small, hollow copper cylinders, containing fulminate of mercury or a mixture of fulminate of mercury and potassium chlorate. These caps are used for detonating dynamite and other high explosives. They are sensitive to shock and very dangerous.

Blaugas is a colorless inflammable gas, having odor similar to Pintsch gas. It is formed by passing mineral oil into a highly-heated retort; the oil is decomposed, forming gaseous products. The gas is compressed to high pressure, removing liquids that condense during compression. The gas is shipped in steel cylinders at a pressure of approximately 1,500 pounds per square inch. Cylinders require a red (gas) label.

Bleaching Powder is a heavy white powder composed chiefly of calcium hypochlorite. It is often known under the name of chloride of lime. It gives off chlorine gas when heated or brought in contact with acids. It also gives off small amounts of chlorine when exposed to the atmosphere and thus may cause damage to other freight. It is not classed as a hazardous article.

Blue Billy, or Pyrites Cinder, is the residue from burning pyrites in manufacture of sulphuric acid. It is a heavy, dark red material, consisting chiefly of iron oxide.

Bombs, Whistling, are fireworks containing small quantities of potassium picrate, a high explosive. These bombs are not believed to be specially hazardous in transportation, but are classed as special fireworks on account of composition.

Bromine is a heavy, reddish brown liquid, which at ordinary temperatures gives off poisonous, suffocating vapors of the same color. Its odor is very irritating to the eyes and throat. Bromine is not inflammable, but is corrosive and has an oxidizing effect on organic matter. Owing to its oxidizing effect it causes heating when in contact with organic matter and may cause fire. It is shipped in glass bottles, and these bottle should be packed in non-combustible, mineral packing, It is classed as a corrosive liquid for transportation and requires a white label. It is refused by many steamship companies.

Bronzing Liquids usually contain pyroxylin or soluble cotton dissolved in volatile inflammable solvents. Benzine is often used to thin the solution, hence flash point of mixture is generally very low. Risks are due entirely to inflammable nature of the solvent. Classed as inflammable liquid.

Calcium Carbide is a grayish black solid material formed by fusion of lime and coke in an electric furnace. Addition of water to calcium carbide causes formation of acetylene gas. Carbide is not explosive or inflammable. It is always packed in tight metallic containers. The type of container used for this material shipped by water, is defined by the Department of Commerce. Material is not classed as a hazardous article by I. C. C. Regulations.

Calcium Lights and Calcium Light Tubes are steel cylinders always shipped in pairs, one cylinder containing compressed oxygen and the other compressed hydrogen gas. The later is an inflammable gas, and requires the red label, while the former is non-inflammable and requires the green label.

Calcium Oxide (Unslaked Lime or Quicklime), is a white, solid mass obtained by burning limestone. Material is incombustible, but combines with water, giving off a great heat, sufficient to cause ignition of surrounding substances. Risks of transportation are due to contact with moisture or to hot loading. It is not accepted by some steamship companies. It is not classed as a hazardous article by the I. C. C. Regulations.

Calcium Phosphide is a reddish or grayish solid mass, which decomposes on contact with water, forming hydrogen phosphide, which ignites spontaneously, on contact with air. It is used in signal fires. It is classed as an inflammable solid by I. C. C. Regulations, and is refused by many steamship companies. When shipped it must be packed in hermetically sealed metal cans enclosed in metal lined wooden boxes, or it may be shipped in securely closed iron or steel barrels.

Camphene is a mixture of alcohol and turpentine, formerly used as an illuminant but not now shipped. Camphene is also a name used for a solid organic substance resembling camphor, which is not dangerous.

Caps, Blasting Caps, Electric Caps, Exploders, Detonators. (See Blasting Caps.)

Caps, Toy, consist of small portions of a mixture of antimony sulphide, red phosphorus and potassium chlorate, between two layers of paper. These caps are in the form of discs forming one cap, or in strips forming a number of caps. Under the I. C. C. Regulations the weight of explosive material in a single cap is limited to 0.35 grain. Owing to the small size of the units of explosive substance, the risks of transportation are small. The caps do not ignite spontaneously, nor explode in mass from external causes, except when the units exceed the legal limit. They are classed as special fireworks.

Carbolic Acid. (See Acid, Carbolic.)

Carbon Bisulphide (Carbon Disulphide or Bisulphide of Carbon) is a heavy clear colorless to yellow liquid, having a very offensive and characteristic odor. It gives off inflammable vapors at 0° F. This vapor ignites at comparatively low temperatures, a spark or flame not being required, as temperature of a high-pressure steampipe will ignite vapors. Carbon bisulphide is used as a solvent for oils, fats, sulphur, phosphorus and rubber, also to kill vermin. It is classed as an inflammable liquid, and is refused by many steamship companies. It is the most hazardous of any of the inflammable liquids.

Carbon Black, or Lamp Black, consists of light and finely divided carbon. It is obtained by burning oil or gas with a smoky flame. It is used as a pigment. It is considered by some to have risks of spontaneous ignition, but is not classed as an inflammable solid. Occasional fires in shipments are more probably due to sparks remaining from the manufacturing process, or to external sparks.

Carbonic Acid Gas, or Carbon Dioxide, is a non-inflammable gas, which is shipped compressed in steel cylinders. It is used in making carbonated beverages. It requires a green label. It is shipped under high pressures, and occasional accidents are caused by bursting of the cylinders. These cylinders are more liable to burst if exposed to heat, or if roughly handled.

Carbon Oil. (See Hydrocarbon.)

Carbon Tetrachloride is a heavy, colorless liquid of aromatic odor resembling that of chloroform. It is an anaesthetic, but it is dangerous to heart action. It is quite volatile, boiling at 171° F., but is entirely incombustible. It is used as a solvent, and as a fire extinguisher. It is not classed as a hazardous article by the I. C. C. Regulations.

Celluloid is the commonly accepted name for all pyroxylin plastic articles. It is the trade name of the plastic used by one company and objection has been made to its use as including all such plastics. It is a solid material made from nitrocellulose and camphor, together with some solvent. It ignites at low temperatures. It is not generally accepted by the steamship companies.

Celluloid (Pyroxylin Plastic) Scrap, consists of trimmings, clippings, and other waste obtained in the manufacture of celluloid articles, from the sheets, rods or blocks in which it is originally manufactured. Owing to its finely divided condition it is more hazardous than the original celluloid. It is classed as an inflammable by the I. C. C. Regulations and is not accepted by the steamship companies.

Cement, Leather. (See Cement, Rubber.)

Cement, Shoe. (See Cement, Rubber.)

Cement, Naphtha. (See Cement, Rubber.)

Cement, Liquid, N. O. S., may be a roofing cement or a rubber cement, etc.

Cement, Roofing, generally consists of a mixture of pitch, tar or asphalt, with some more or less inflammable liquid solvent. The inflammability will depend on amount and character of the solvent remaining in finished cement.

Cement, Rubber, is a heavy solution of rubber in gasoline or carbon bisulphide. It is highly inflammable, having a flash test at or near 0° F. It is classed as an inflammable liquid.

Charcoal is the product of the destructive distillation of wood. It is a highly porous substance, and has the property of absorbing great quantities of various gases. When freshly burned, this absorption sometimes proceeds so rapidly as to cause the spontaneous ignition of the coal. Freshly burned, wet, or finely divided charcoal, especially the hard wood charcoal made in ovens or retorts, is most liable to this risk. It is classed as an inflammable solid.

Charcoal Tablets are small tablets made by compression of powdered charcoal usually mixed with some binding material. Owing to the small bulk in packages and the presence of other ingredients these tablets are not regarded as hazardous.

Chemicals, N. O. S., may include materials classed as inflammable liquid, inflammable solid, oxidizing material or corrosive liquid.

Chili Saltpetre (Sodium Nitrate). (See Nitrates.)

Chlorate of Barium. (See Chlorate.)

Chlorate of Potassium. (See Chlorate.)

Chlorate of Sodium. (See Chlorate.)

Chlorates are salts of such bases as barium, strontium, sodium and potassium, etc., and are generally spoken of as barium chlorate, strontium chlorate, sodium chlorate, and potassium chlorate. There are also chlorates of other bases, but the ones mentioned above are the most important. All the chlorates are in the form of white crystalline salts and are strong oxidizing agents. Mixed with organic matter, they form very inflammable mixtures, and frequently act as high explosives, when mixed with finely divided combustible material. All chlorates when brought in contact with sulphuric acid are liable to cause fire or explosion. Mixtures of chlorates with organic matter may be ignited by friction. Barium chlorate and strontium chlorates, are principally used in fireworks. Potassium chlorate is used in fireworks and explosives. Sodium chlorate is used to some extent in explosives. Chlorates are commonly shipped in wooden kegs and are classed as oxidizing materials by the I. C. C. Regulations. Their shipment is also restricted by the Department of Commerce.

Chlorate Tablets. Small tablets consisting wholly or in part of potassium chlorate are used medicinally for sore throat, etc. These, if in large bulk, possess same hazards as the chlorate in any other form. Packed in bottles in small units they possess no particular risk.

Chloride of Phosphorus, or Phosphorus Trichloride is a fuming, colorless liquid, strongly corrosive. It acts strongly on organic matter, producing great heat. Bottles containing this liquid should be packed in non-combustible, mineral packing. It is classed as a corrosive liquid by the I. C. C. Regulations. It is not accepted by some steamship companies.

Chloride of Silicon is a colorless liquid, fuming strongly in air. It has a suffocating odor. Mixed with water, it decomposes, forming hydrochloric acid. It is classed as a corrosive liquid by the I. C. C. Regulations. It is not accepted by some steamship companies.

Chloride of Sulphur, or Sulphur Chloride, is a yellow to reddish corrosive fuming liquid. It is a solvent for sulphur, and is used in vulcanizing rubber. It is classed as a corrosive liquid by the I. C. C. Regulations. It is not accepted by some steamship companies.

Chlorine Gas is a heavy, greenish yellow gas of suffocating, irritating odor. It is used for bleaching, and also for de-tinning iron, and is shipped liquefied in steel cylinders. It is very poisonous, but not combustible. It requires a green label. It is not accepted by some steamship companies.

Chromic Acid (Anhydrous) is in the form of reddish brown crystals. Material is caustic and a powerful oxidizing agent. Mixed with organic matter it may ignite spontaneously or explode, and in such mixtures it is always highly combustible. In shipment it must be kept away from organic matter and moisture. It is classed as an oxidizing material. It is not accepted by some steamship companies.

Cleaning Fluids frequently consist largely of gasoline, naphtha, or other inflammable, volatile solvents, in which case they are classed as inflammable liquids.

Coal Gas is the gas obtained by the destructive distillation of bituminous coal. It is chiefly used for lighting and heating purposes in towns and cities, being distributed for this purpose through pipes at very low pressure. A relatively small amount of coal gas is compressed and used for welding. The compressed gas is shipped in steel cylinders; the maximum pressure to which it is compressed is approximately 2,000 lbs. per sq. inch. For transportation purposes it is classed as Compressed Gas Inflammable and requires a red (gas) label.

Coal Oil. (See Kerosene.)

Coal Tar Distillate. (See Benzole.)

Coal Tar Naphtha. (See Benzole.)

Coal Tar Oil. (See Benzole.)

Collodion is a solution of nitrocellulose in a mixture of ether and alcohol. It has a flash test of approximately 0° F. It is classed as an inflammable liquid. It is not accepted by some steamship companies, and its shipment is restricted by the Department of Commerce.

Cologne Spirits. (See Alcohol, Grain.)

Columbian Spirits. (See Alcohol, Wood.)

Common Fireworks include all that depend principally upon nitrates to support combustion and not upon chlorates; that contain no phosphorus and no high explosive sensitive to shock and friction; that produce their effect through color display rather than by loud noises. If noise is the principal object, the units must be small and of such nature and manufacture that they will explode separately and harmlessly, if at all, when one unit is ignited in a packing case. They must not be designed for ignition by shock or friction. Examples are Chinese firecrackers, Roman candles, rockets, pin wheels, colored fires, serpents, railway fusees, flash powders, etc.

Compounds, Cleaning, may contain gasoline or other inflammable solvents. In this case they will be classed as inflammable liquids.

Compounds, Polishing, N. O. S. Many liquid polishing compounds contain an abrasive material held in suspension by gasoline or some other inflammable liquid.

Compounds, Type Cleansing, may contain gasoline or other similar inflammable liquid.

Compounds, Vulcanizing, may include rubber cements, which are inflammable liquids, or sulphur chloride, which is classed as a corrosive liquid.

Cordeau detonant is a fuse consisting of a thin walled lead tube approximately 1/6 inch in diameter filled with finely powdered trinitrotoluol. This cordeau detonant can be exploded only by attaching a blasting cap to the lead tube in a peculiar way. Otherwise it is non-hazardous, and can be shipped without any restriction, except that it must not be loaded in the same package with blasting caps or high explosive.

Cotton. This material is generally shipped in bales. It is not liable to spontaneous ignition, but is readily ignited by very small sparks, and is capable of maintaining a smoldering combustion for a number of days before breaking openly into flame. When once ignited it is impossible to extinguish fire without pulling bales entirely apart. The cotton, if contaminated with animal or vegetable oils, is liable to spontaneous ignition. In this way linseed oil is the greatest hazard.

Cotton, Burnt, is cotton which has been on fire, and has not been subsequently repicked and rebaled. Such cotton is liable to retain fire inside the bales, and maintain a smoldering combustion for a long time, and ultimately break out into open flame. This "burnt cotton" is classed as a yellow label inflammable, and must not be offered or accepted for shipment until not less than five days have elapsed since the last evidence of fire in it.

Cotton, Soluble. (See Nitrocellulose.)

Cotton, Waste, of itself is not liable to spontaneous ignition, but when oily or greasy with animal or vegetable oils, it is liable to spontaneous heating and ignition. The ordinary oily cotton wastes contain mineral lubricating oils, and are not liable to spontaneous heating. Cotton waste containing more than 5 per cent animal or vegetable oils is a forbidden article under the I. C. C. Regulations.

Cresote, or Cresote Oil, is a heavy, brownish liquid of peculiar, characteristic, penetrating odor. It is combustible, but the flash point is high. It is used largely as a preservative for lumber. Shipment is refused by some steamship lines on account of objectionable odor. Its shipment is restricted by the Department of Commerce.

Creosoted Lumber is lumber which has been treated with creosote. Shipment is refused by some steamship lines on account of objectionable odor.

Crude Oil, as it comes from the well is a heavy, oily liquid, having color varying from green to almost black. It usually has a disagreeable odor, and varies in inflammability according to percentage of more volatile ingredients. Crude oils produced in the east are generally very inflammable, while many of those from the south and west have flash point above 100° F.

Crude Petroleum. (See Crude Oil.)

Cyanide of Potash. (See Potassium Cyanide.)

Cymogen is one of the most volatile of the distillates from crude petroleum. It has a flash test of 0° F. It is classed as an inflammable liquid. This term is but little used.

Dental Gas is nitrous oxide gas. Is a colorless, incombustible gas of pleasant odor. It is shipped compressed and liquefied in steel cylinders. It is used as an anaesthetic by dentists, but is not otherwise hazardous. It requires a green (gas) label.

Desiccated Leather Scrap consists of leather scrap that has been digested with steam, either with or without addition of acid, and then dried and powdered. The drying is frequently of such nature as to partially char the material, causing the freshly finished product to be subject to spontaneous ignition in same way as freshly burned charcoal.

Detonating Fuses are used to detonate the high explosive bursting charges of projectiles or torpedoes. In addition to a powerful detonator they may contain several ounces of a high explosive, such as picric acid or dry nitrocellulose, all assembled in a heavy steel envelope, the flying fragments of which, in case of explosion, would be very dangerous. From their careful design, manufacture, and packing, detonating fuses are not liable to be exploded in transportation except by fire of considerable intensity.

Detonators. (See Blasting Caps.)

Dip, Sheep, sometimes contains inflammable liquid ingredients.

Disinfectants, Liquid. Some few liquid disinfectants may contain inflammable liquids, and as such would be so classed. Most of the liquid disinfectants are not classed as inflammable, but are sometimes objectionable on account of odors of essential oils or formaldehyde.

Distillates may include petroleum or coal tar products of low flash point.

Drier, Paint, and Japan, N. O. S. If liquid, may include volatile solvents, and require classification as inflammable liquid.

Driers are liquids added to paints or varnishes to improve their drying qualities. They frequently contain volatile solvents such as benzine and may therefore be classed as inflammable liquids.

Dross, Lead, is a term properly applied to the material skimmed from the surface of molten lead. This material when cold is entirely non-hazardous. The term is sometimes improperly applied to the scrap from the lead chambers used in making sulphuric acid. This material is more or less saturated with sulphuric acid and is commonly refused by steamship lines.

Dross, Zinc, is a term properly applied to the material skimmed from the surface of modern zinc, and is a by-product of galvanizing iron. This dross is entirely non-hazardous. The term zinc dross is sometimes applied to zinc dust, which is an inflammable solid under the I. C. C. Regulations.

Drugs, N. O. S. (See Chemicals, N. O. S.)

Drums, Empty. (See Barrels, Empty.)

Dynamite is any high explosive formed by the mixing of nitroglycerin with an absorbent material so as to form a plastic solid.

Electric Primers consist of small brass tubes containing compressed black powder and small pieces of platinum resistance wire. Copper wires are attached externally to one end of primer, which bears a slight superficial resemblance to an electric blasting cap. Electric primers are used for firing cannon, and are comparatively safe for shipment. When accepted for either rail or boat shipment, they must be packed and marked according to I. C. C. Regulations.

Eradicator, Paint or Grease, frequently contains ether or gasoline, and is, therefore, then classed as an inflammable liquid.

Ether (Sulphuric Ether) is a clear, colorless, highly volatile and inflammable liquid. It has a peculiar pungent odor, boils at temperature of 97° F. and gives a flash test at 0° F. It is made by treatment of alcohol with sulphuric acid. It is used medicinally as an anaesthetic, technically as a solvent of fats, oils, rosins, etc., and mixed with alcohol as a solvent for nitrocellulose in manufacture of smokeless powder. It is classed as an inflammable liquid. Its shipment is restricted by Department of Commerce, and it is not accepted by many steamship companies.

Ether, Petroleum, is a very light and volatile petroleum distillate. It is more inflammable than ordinary gasoline, and is principally used as a solvent.

Ethyl Acetate. (See Acetate of Ethyl.)

Ethyl Alcohol. (See Alcohol, Grain.)

Ethyl Chloride is a colorless highly volatile and inflammable liquid, which boils at 55° F. Consequently, unless confined in hermetically sealed containers, it will immediately evaporate at ordinary temperatures. It is used as an anaesthetic. It is the usual practice to ship this material in sealed glass or metal tubes, and, on account of the secure method of packing and small quantity shipped, it is not mentioned in the list of dangerous articles in the regulations.

Ethyl Methyl Ketone is a colorless inflammable liquid, somewhat resembling acetone in its properties, and is used for a similar purpose. It has a flash point of approximately 30° F. It is classed as an inflammable liquid.

Ethyl Nitrite is a thin, yellowish liquid, boiling at 61° F. It is exceedingly volatile and inflammable, and has an odor somewhat like apples. It may ignite spontaneously in storage at a temperature of 194° F., or if mixed with fat or other organic matter at 167° F. It is usually shipped in alcoholic solution containing 15 per cent ethyl nitrite. This solution is also exceedingly volatile and inflammable. Ethyl nitrite, either pure or in 15 per cent solution, should be packed in sealed glass tubes. It is chiefly used in making spirits of nitrous ether, a medicinal preparation containing 4 per cent ethyl nitrite. Spirits of nitrous ether is somewhat more inflammable than ordinary alcohol. All of these preparations are classed as inflammable liquids.

Excelsior is shredded wood used as a packing material. Owing to its finely divided form, it is readily ignited by sparks, and therefore not carried by some steamship lines.

Explosive Projectiles, or loaded shells for use in cannon, are not liable to be exploded except by fire of considerable intensity, and the flying fragments would then be very dangerous.

Extracts, N. O. S. Extracts may be dried powders, water solutions, or alcoholic solutions; in the last case they may be classed as inflammable liquid.

Ferro Silicon is a compound of iron and silicon. It occasionally gives off poisonous gas when in large bulk, and especially if wet. When shipped by water, should be on deck or in well-ventilated portion of hold away from quarters of passengers and crew. It is not classed as a dangerous article for rail transportation, but is not accepted by some of the steamship companies.

Fertilizers. Mixed or complete commercial fertilizers have little or no fire hazard. Separate ingredients such as desiccated leather scrap or tankage, spent iron oxide, garbage tankage and partially charred organic residues, are often improperly shipped under the name of fertilizer. Some of these ingredients in bulk are liable to spontaneous ignition.

Fiber. Commercial fibers, such as cocoa, jute, palmetto, etc., are required to be baled for shipment, and owing to inflammability, are not accepted at all by some steamship lines, and only under certain restrictions by others.

Fiberloid. (See Celluloid.)

Fillerine (fertilizer ingredient) is waste iron oxide which has been used for the purification of coal gas. It is liable to spontaneous combustion on exposure to air. It is added to fertilizers to produce bulk rather than for any fertilizing value.

Fire, Colored or Tableau, are pyrotechnic mixtures for illuminating and signal purposes. These mixtures usually contain chlorates, and often sulphur. Mixtures containing both chlorate and sulphur are liable to spontaneous ignition. All such mixtures are classed as common fireworks when accepted for shipment.

Fireworks include everything that is designed and manufactured, primarily, for the production of pyrotechnic effects. They consist of common fireworks and special fireworks.

Flue Dust consists of finely divided dust, either carbonaceous in form of soot, or metallic, containing zinc, etc. Some of these dusts contain large proportion of zinc in a metallic condition, and these are inflammable. Others contain zinc as oxide and are non-hazardous.

Freezing Point of Alcoholic Liquids, etc. The freezing points of mixtures of ethyl alcohol and water are given in Landolt & Bornstein's tables. They are as follows:

Per Cent. Alcohol.	Freezing Point.	
2.4%	30.2°	Fahr.
5.0%	28.4°	"
8.1%	26.0°	"
17.9%	18.5°	"
36.4%	3.2°	"
51.0%	—10.0°	"
86.2%	—30.0°	"

It will, therefore, be seen that practically all alcoholic liquors are liable to freeze in extreme temperature at times prevalent in the Northwest. While it is possible to freeze some other liquids, water or water solutions are the only ones which expand on freezing.

It is believed that no damage will result from the freezing of any liquid other than alcoholic liquors, or other liquids which consist of solutions in water.

Fusees are colored fire mixtures placed in pasteboard tubes. Mixtures sometimes contain both sulphur and chlorate, and in this case are somewhat liable to spontaneous ignition, especially if old or damp. Must be designated as common fireworks for shipment. Potassium perchlorate is at present being much substituted for potassium chlorate in these products, much reducing the chances of accidental or spontaneous ignition.

Fuses, Platinum, are made from platinum wire, and are used as igniters over gas jets, etc., causing ignition when exposed to coal gas or alcoholic vapors.

Fulminate of Mercury is a heavy grayish powder of crystalline form. It is formed by the action of nitric acid and alcohol on metallic mercury. This material is one of the most sensitive and dangerous of explosive substances. It is used principally in the manufacture of detonators, blasting caps and primers.

Fulminate of Silver is a grayish white crystalline material used in toy torpedoes. It is even more sensitive than mercury fulminate, and cannot be shipped in bulk by rail.

Fusel Oil (Amyl Alcohol) consists of a colorless to yellowish liquid having a penetrating, disagreeable odor resembling that of bad whiskey. It is produced in the fermentation of starch and sugar, and is separated from grain alcohol. Fusel oil being a mixture of various higher alcohols, and varying in purity, has no definite flash test. So far as known all the commercial fusel oil has a flash point above 80° F. and is therefore not classed as an inflammable liquid. The flash point is commonly from 100° to 110° F. It is generally accepted by the coast steamship companies, and much is imported.

Garbage Tankage, a product from digestion and extraction of garbage, consists mainly of vegetable fibers; it sometimes causes spontaneous ignition and is refused by some steamship companies.

Gas Oil may be a product of low flash point.

Gasoline. (See Benzine.)

Gas Purifying Waste (fertilizer ingredient). (See Iron Mass, Spent.)

Grease Eradicator. (See Eradicator.)

Greek Fire is colored fire mixture used for pyrotechnic purposes. Must be designated as common fireworks.

Gun Cotton. (See Nitrocellulose.)

Hay, Baled, owing to its inflammability, is not accepted by some steamship lines.

Hemp, when baled, is accepted by some steamship lines and not by others. When loose it is accepted by none.

High Wines. (See Alcohol, Grain.)

Hydrocarbon is a liquid that condenses on compression of Pintsch gas. It is highly inflammable, having a flash test of 0° F. It is classed as an inflammable liquid.

Hydrochloric Acid. (See Acid, Hydrochloric.)

Hydrogen Gas is a colorless, odorless, inflammable gas, shipped compressed in steel cylinders. It requires red (gas) label.

Hydrofluoric Acid. (See Acid, Hydrofluoric.)

Hydrocyanic Acid. (See Acid, Hydrocyanic.)

Insect and Vermin Destroying Preparations frequently contain carbon bisulphide, gasoline, naphtha or other inflammable liquids. Such preparations are classed as inflammable liquids.

Iron Mass is a mixture of wood shavings with a hydrated ferric oxide. If carefully made and properly oxidized, it is entirely safe. If an undue amount of unoxidized iron remains, further oxidation is liable to occur, causing sufficient heat in closely packed material to cause fire. Material is used to remove sulphur from coal gas. If properly prepared it is not classed as an inflammable by the I. C. C. Regulations, but if not properly prepared it is a forbidden article and is refused by most of the steamship companies. If not properly oxidized it is classed as a forbidden article by the I. C. C. Regulations.

Iron Mass, Spent (Iron Sponge, Spent) consists of the iron mass or sponge after saturation with sulphur in gas purification. The spent material is liable to spontaneous combustion on exposure to air. At the present time there is little traffic in this material.

Iron Sponge. (See Iron Mass.)

Iron Sponge, Spent. (See Iron Mass, Spent.)

Japan Drier. (See Drier, Japan.)

Iron Turnings, Borings, Filings, when in large bulk, have a fire hazard, as they oxidize spontaneously if wet and the oxidation may produce enough heat for ignition. This risk is not sufficient to cause material to be classed as inflammable by I. C. C. Regulations and material is accepted by steamship companies.

Kerosene is a petroleum distillate commonly used for lighting purposes It has a flash point approximately 115-125° F., and is not classed as an inflammable liquid by the I. C. C. Regulations. It is not accepted by some of the steamship companies.

Ketone, Methyl or Ethyl. (See Ethyl Methyl Ketone.)

Laboratory Supplies, N. O. S. (See Chemicals, N. O. S.)

Lacquer usually consists essentially of nitrocellulose dissolved in a volatile solvent or a mixture of volatile solvents. Inflammability depends on the character of these solvents. It is classed as an inflammable liquid.

Lacquer (Shellac) consists of a solution of shellac in alcohol and has a flash test of about 40-70° F. It is classed as an inflammable liquid.

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Lead Nitrate is a heavy white translucent salt, which is an oxidizing agent. It is used medicinally, and in the color industry. It is commonly shipped in barrels and boxes and when so packed is not classed as an oxidizing material by the I. C. C. Regulations.

Leather Cement is a solution of rubber in gasoline or carbon bisulphide, and is consequently very inflammable, having a flash test of approximately 0° F. It is classed as an inflammable liquid.

Leather Meal. (See Dessicated Leather Scrap.)

Leather Scrap. (See Dessicated Leather Scrap.)

Ligroin is the more volatile distillate from crude petroleum; it has a flash test of 0° F. It is classed as an inflammable liquid. This term is seldom used.

Lime. (See Calcium Oxide.)

Light Oil. (See Benzole.)

Liniments frequently contain crude petroleum, ether, alcohol and other volatile inflammable liquids.

Liquid Bronze. (See Bronzing Fluids.)

Liquids, N. O. S. Classification depends on character.

Liquefied Petroleum Gas is the liquid condensed by compressing the gas from petroleum oil wells, known as casing head gas. For transportation purposes the term is applied only to such products whose vapor tension at 100° F. exceeds 10 lbs. per square inch.

When the vapor pressure at 100° F. does not exceed 10 lbs. per square inch, it may be shipped as gasoline. When the vapor pressure at 100° F. lies between 10 lbs. and 25 lbs. per square inch, shipments must be made in metal kegs, drums or barrels complying with I. C. C. Specification No. 5, or in specially built tank cars. Such material is classed as inflammable liquid.

When the vapor pressure at 100° F. exceeds 25 lbs. per square inch, material must be shipped as a compressed gas.

Luxor Oil is a trade name for a certain make or grade of petroleum oil used for burning and illuminating. It is not classed as an inflammable liquid.

Magnesium, Metallic, is a white metal; in mass it is non-hazardous, but in form of powder or ribbon it is highly inflammable, burning with intense heat and light. It is used in flashlight powder and pyrotechnics. In powdered form it is classed as an inflammable solid.

Matches, "Strike Anywhere" usually contain phosphorus sesquisulphide and potassium chlorate, together with other ingredients. Under the present Federal law the manufacture or importation of matches containing yellow or white phosphorus is not probable. The new matches are non-poisonous, but have about the same fire hazards as those containing the yellow or white phosphorus. The temperature of ignition is much higher than with the old phosphorus match, but sensitiveness to impact and friction is about the same. The risks in transportation are about the same as with the old match. When a package of matches is ignited by impact or friction, the head composition burns off the matches, and the fire generally goes out unless the package is broken. If the package is broken, allowing access of air, the fire will continue. Strike Anywhere Matches are classed as inflammable solids.

Matches, N. O. S., may be either "strike anywhere" or "strike on box" matches. In former case they are classed as inflammable.

Matches, "Strike on Box," are those that are supposed to strike only on the prepared surface of the box. They can, however, usually be ignited by rubbing on glass, linoleum, or on a smooth, unvarnished surface. The active principle of the head composition is potassium chlorate, while the prepared surface on box contains red phosphorus.

EDITOR'S NOTE.—The Underwriters' Laboratories label one manufacturer's matches as meeting the following requirement:

Class A, or Strike-on-Box.—These have heads made of a stable chemical compound with heat ignition point exceeding 340 degrees Fahrenheit and with low susceptibility to ignition by shock and with the explosive character and the fly hazard during combustion reduced so far as is at present practicable for this type of match and have strong splints, treated to prevent afterglow.

Class B, or Strike-Anywhere.—These have heads made of stable chemical compounds with heat ignition point exceeding 300 degrees Fahrenheit, and especially well safeguarded against ignition by shock, with practically no explosion or fly hazard during combustion and with the inert bulb (not ignitible by friction) preventing to a large degree the accidental ignition of the tip, and have strong splints treated to prevent afterglow.

Mercuric Chloride, or Corrosive Sublimate, is a heavy white salt in form of powder or lumps. It is very poisonous, but not otherwise hazardous for shipment. It is not accepted by some steamship lines.

Metallic Potassium and Metallic Sodium are soft white metals of silvery lustre on freshly cut surface, similar in appearance to freshly exposed surface of lead. These metals are very readily oxidized, and contact with water will cause ignition. They are, therefore, packed in mineral oil to protect from air or water, or in hermetically sealed tin cylinders or metal drums. The chief risk with these metals is that they may be brought in contact with water. They are classed as inflammable solids.

Metal Polish, Liquid. (See Polish.)

Methyl Alcohol. (See Alcohol, Wood.)

Mirbane Oil, or Mono-Nitro-Benzol, is a heavy oily liquid of yellow to brownish color, and having the odor of bitter almonds. Material is not very inflammable, having a flash test of approximately 200° F.

Moss, Florida. This material, owing to fibrous nature, is readily ignited by sparks, etc.

Moving Picture Film consists largely of nitrocellulose and has risks similar to pyroxylin plastics, but to a greater degree. Material may be ignited by sparks or by proximity to steam pipes or other sources of heat. Material when ignited burns with extraordinary and almost explosive rapidity. Rolls of films should be packed in strong and tight boxes, complying with the I. C. C. Regulations. They are classed as inflammable solids when shipped by express. There are some non-inflammable films made of cellulose acetate. Owing to the higher cost, and lack of durability of this kind of film, the amount used is negligible.

Muriatic Acid. (See Acid, Hydrochloric.)

Naphtha. (See Benzine or Benzol.)

Naphtha Cement. (See Leather Cement.)

Naphtha, Coal Tar. (See Benzol.)

Naphtha Soap is a soap said to contain a small percentage of naphtha. This soap is alleged to have caused fire and explosion several years ago in a ship's hold at Liverpool. It is not received by some of the steamship lines, but is not classed as an inflammable by the I. C. C. Regulations.

Naphtha, Wood. (See Alcohol.)

Naphthalene (Coal Tar Camphor) is a white crystalline solid, having odor somewhat similar to camphor. Material is readily ignited by sparks.

Negative Cotton. (See Nitrocellulose.)

Neutral Spirits. (See Alcohol, Grain.)

Nitrate of Barium. (See Barium Nitrate.)

Nitrate of Lead. (See Lead Nitrate.)

Nitrate of Potassium. (See Potassium Nitrate.)

Nitrate of Soda. (See Sodium Nitrate.)

Nitrate of Strontia. (See Strontium Nitrate.)

Nitre. (See Potassium Nitrate.)

Nitrite. (See Sodium Nitrite.)

Nitric Acid. (See Acid, Nitric.)

Nitrating Acid. (See Acid, Mixed.)

Nitro-Benzol. (See Mirbane Oil; see Trinitro Benzol.)

Nitrocellulose is formed by the nitration of cotton by treatment with a mixture of nitric and sulphuric acids. After removal of acid the product is dried. It then has the same physical form as the original cotton, but is highly inflammable and explosive. Sometimes the nitrocellulose is pulped before drying, and is then in form of a fine light powder rather than in fibrous condition.

Nitrocellulose when dry, is shipped under requirements for high explosives. When wet with volatile solvent or dissolved in solvents it is classed as an inflammable liquid. When wet with not less than 20 per cent of water it is classed as an inflammable solid.

Nitroglycerin is obtained by nitration of glycerin with a mixture of nitric and sulphuric acids. It is a heavy oily liquid of yellowish color resembling glycerin in appearance. It is highly explosive and dangerous, and shipment is prohibited.

Nitroglycerin Spirits is a solution of nitroglycerin of not more than 10 per cent strength in grain alcohol. It is used for medicinal purposes. The inflammability of this solution is the same as that of grain alcohol. It is not explosive, but rupture of package may allow alcohol to evaporate, and thus leave the explosive nitroglycerin. On account of the practice of shipping this article in small units, seldom exceeding four ounces of one per cent solution in quantity, it is not mentioned in the list of dangerous articles in the regulations.

Nitrotoluol. There are various compounds shipped as nitrotoluol, for example, dinitrotoluol, mononitrotoluol, and trinitrotoluol, some liquid and some solid. None of the liquid nitrotoluols are explosive or dangerous. Of the solid nitrotoluols, trinitrotoluol is the only one classed as a high explosive.

Nitrous Ether. (See Ethyl Nitrite.)

Oil, Dead, is the heavy oil distilled from coal tar after the distillation of the light oil. This heavy oil is not very inflammable, having a high boiling point and flash test. It is not classed as an inflammable liquid by the I. C. C. Regulations.

Oil, Mirbane. (See Mirbane Oil.)

Oil, Petroleum, N. O. S. Classification depends on flash point.

Oil, Rosin, Light, is distilled from rosin. It is a light oil, having about the same degree of inflammability as turpentine.

Oil of Turpentine. (See Turpentine.)

Oil of Vitriol. (See Acid, Sulphuric.)

Oxygen is a colorless, odorless, non-inflammable gas. It is shipped compressed in steel cylinders. It requires a green (gas) label. Some of these cylinders contain the oxygen under very high pressures, approximately 2,000 lbs. per square inch. It is not accepted by some steamship companies.

Paint, Aluminum. (See Bronzing Liquid.)

Paint, Bronzing. (See Bronzing Liquid.)

Paint, Gold. (See Bronzing Liquid.)

Paints, Liquid, are paints in which the pigment is generally of mineral or metallic origin; the inflammability of these paints depends wholly on the nature of the liquid ingredients.

Paint Removers frequently contain wood alcohol, naphtha or other inflammable solvents, and such materials are classed as inflammable liquids.

Paper, Waste. Old or scrap paper shipped in bales is readily ignited by sparks. It is also liable to have a fire hazard owing to the accidental presence of matches, oily waste, and other foreign articles.

Paraffin Oil is a heavy non-volatile petroleum oil of high flash test. It is not accepted by some steamship lines.

Paste, Shoe, may be a solution of rubber in gasoline or carbon bisulphide, and therefore would be classed as an inflammable liquid.

Pentane is a clear, colorless, volatile liquid, having a pleasant odor. It has a specific gravity of 0.63, and boils at temperature of 95° F. or less. It gives a flash test at or below 0° F. and is consequently highly inflammable. It is obtained from the more volatile portions of petroleum, and is used as a standard in determining candle power of various lights and illuminants. Material is about the same inflammability as 88° naphtha. It is classed as an inflammable liquid.

Perchlorate of Potash. A white crystalline solid, used as an oxidizing agent in fireworks and explosives. It is classed as an oxidizing material by the I. C. C. Regulations. It is not accepted by some steamship companies.

Petroleum Ether. (See Benzine.)

Petroleum Spirit. (See Benzine.)

Petroleum Naphtha. (See Benzine.)

Petroleum Oil may include any oil derived from crude petroleum, but usually term is used to indicate the ordinary illuminating oil. The classification as to inflammability will depend on flash test.

Petroleum Products, N. O. S. Classification as to inflammability will depend on flash point.

Phenol. (See Acid, Carbolic.)

Phosphorus, Red or Amorphous, is different in physical form from yellow phosphorus. It is a reddish brown powder, not spontaneously inflammable, nor poisonous. It is not dangerously inflammable, and is not classed as inflammable, and its shipment is not restricted by either the railways or steamship lines.

Phosphorus, Yellow, is a yellow, waxy solid of peculiar characteristic odor. It is highly inflammable and will ignite at ordinary temperature if exposed to the air. It is usually shipped under water. Beside being inflammable, it is very poisonous. It is classed as an inflammable solid. It is not generally accepted by the steamship companies.

Phosphorus, White. (See Phosphorus, Yellow.)

Pintsch Gas is formed by heating fuel oil in a retort. The gas produced is compressed, the condensed liquid is drawn off, and the dry compressed gas is stored in iron or steel tanks. Its chief use is for lighting railway coaches. It is shipped in metal cylinders and requires the red (gas) label.

Pitch Roof Coating. (See Cement, Roofing.)

Platinum Fuse (Platinum Black) is finely divided metallic platinum, which causes spontaneous ignition of mixtures of air and inflammable vapors or gases. It is used in patent cigar and gas lighters, also in some chemical apparatus.

Polish, Liquid. May contain inflammable liquid ingredients, of such character as to make flash test of mixture 80° F. or lower.

Polishing Liquids. (See Polish.)

Potash, N. O. S., may include nitrate, chlorate or permanganate of potash, and therefore be classed as an oxidizing material.

Potassium Chlorate. (See Barium Chlorate.)

Potassium Cyanide is a heavy white solid material, highly poisonous, but not otherwise hazardous. It is used in recovering precious metals, in case hardening and electro-plating. It is not accepted by some steamship lines, but is not classed as a hazardous article by the I. C. C. Regulations.

Potassium Metallic. (See Metallic Potassium.)

Potassium Nitrate is a white crystalline salt, which acts as an oxidizing agent. It is used to some extent chemically, and largely in the manufacture of black rifle powder. It is commonly shipped in barrels or boxes, and when so packed is not classed as dangerous by the I. C. C. Regulations.

Potassium Permanganate is a purplish crystalline salt, soluble in water, giving a highly colored solution. It is very rich in oxygen and may cause fire when mixed with combustible material. Contact with sulphuric acid will also cause fire. It is classed as an oxidizing material by the I. C. C. Regulations. It is not accepted by some steamship companies. It should never be packed in the same outside container with formaldehyde.

Potassium Peroxide. (See Sodium Peroxide.)

Preparations, Insect and Vermin Destroying, if liquid, sometimes contain carbon bisulphide or gasoline, and would in such case be classed as inflammable liquids.

Preservers, Iron, Steel, or Wood, may contain volatile inflammable liquids sufficient to lower flash test to 80° F. or below.

Primers, Electric. (See Electric Primers.)

Primers, Percussion and Time Fuses are devices used to ignite the black powder bursting charges of projectiles, or the powder charges of ammunition. For small-arms ammunition the primers are usually called " small-arm primers " or " percussion caps."

Proof Spirits. (See Alcohol, Grain.)

Prussic Acid. (See Acid, Hydrocyanic.)

Pyralin. (See Celluloid.)

Pyroxylin. (See Nitrocellulose.)

Pyroxylin Plastic. (See Celluloid.)

Pyroxylin Solutions consist of pyroxylin, nitrocellulose, or soluble cotton dissolved in amyl acetate, or other solvent. The pyroxylin solutions are used as a basis for the manufacture of lacquer, leather coating compounds, leather substitutes, etc., and are generally thicker than ordinary lacquers, but have no greater fire hazard. They are classed as inflammable liquids.

Rags, Old, are refused by certain steamship lines owing to the fire risk. Old rags are commonly very dirty and if oily or wet are liable to spontaneous heating or ignition. Rags containing more than 5 per cent animal or vegetable oil, and wet rags are prohibited articles under the I. C. C. Regulations.

Railway Fusees. (See Fusees.)

Railway Torches. (See Fusees.)

Railway Torpedoes. (See Torpedoes, Track.)

Removers, Paint, Oil or Varnish. (See Paint Removers.)

Rhigolene. (See Benzine.)

Rice Straw is refused by certain steamship lines due to liability to fire from sparks, etc.

Rosin Dross. (See Batting, Dross.)

Rubber, Regenerated, Shoddy, or Reclaimed, consists of old rubber which has been subjected to chemical treatment of various kinds to prepare it for further use in the rubber industry. Some grades of these regenerated, shoddy or reclaimed rubbers are liable to spontaneous ignition. According to the I. C. C. Regulations these rubbers must be packed in tight metal containers, or in wooden boxes complying with Shipping Container Specification No. 17, except when in the form of dense, homogeneous, non-porous sheets, or rolls, the sheets of thickness of ⅛ inch or greater packed flat or in rolls.

Certain grades of rubber scrap if ground, powdered, or granulated, are also subject to this risk of spontaneous ignition. Such scrap containing more than 45 per cent rubber must also be shipped in tight metal containers or in wooden boxes complying with Shipping Container Specification 17. Regenerated, reclaimed, or shoddy rubbers, or ground rubber scrap requiring this special packing are classed as inflammable solids under the I. C. C. Regulations.

Rubber Cement, Rubber Solution. (See Cement, Rubber.)

Safety Fuse consists ordinarily of a core of fine grain black powder, which is surrounded by yarn, tape, pitch, rubber, etc. Squibs are merely small paper tubes containing a small quantity of black powder, one end of each tube being twisted and generally tipped with sulphur.

Saltpetre. (See Potassium Nitrate.)

Shavings, Wood, are refused by some steamship lines, due to risk of fire from sparks or other external causes.

Shellac, Liquid, is a solution of shellac in grain alcohol or denatured alcohol. It has flash test of 40-70° F., respectively, according to solvent. It is classed as an inflammable liquid.

Small-arms Ammunition. (See Ammunition.)

Sodium Metallic. (See Metallic Sodium.)

Sodium Nitrate is a white or yellowish white salt, imported in large amount from Chili. It is used very largely in fertilizers, in explosives, and in the manufacture of nitric acid. It is hygroscopic, and is therefore liable to be quite damp. It is commonly shipped in jute bags of approximately 200 pounds capacity. When so packed it is classed as an oxidizing material by the I. C. C. Regulations. If for any reason it is packed in boxes, barrels or kegs as are the other nitrates it is not classed as an oxidizing material.

Sodium Nitrite is a yellowish white salt, somewhat moist in appearance. It is an oxidizing material which, while containing less oxygen than the nitrates, is more readily decomposed, and therefore generally more active. When mixed with organic matter, it is more readily ignited than a corresponding mixture of sodium nitrate. It is used in the manufacture of dyes. Material is rather hygroscopic, and is commonly shipped in barrels, casks or cases, and not in bags.

Sodium Peroxide, or Potassium Peroxide, is a white or yellowish white powder possessing very strong oxidizing properties. It is decomposed by water or acids. In contact with organic matter it is ignited by heat, friction or moisture. It is always shipped in tight, metallic containers. It is a hazardous commodity. It is classed as an oxidizing material.

Softener, Leather, may contain inflammable liquids.

Soluble Cotton. (See Nitrocellulose.)

Solvents include such inflammable liquids as acetone, ether, naphtha, etc. Such articles are classed as inflammable liquids. Solvents may have flash points above or below 80° F., according to nature.

Soot consists chiefly of finely-divided carbonaceous matter together with some ammonium sulphate. The presence of latter renders it of value as a fertilizer. It is liable to spontaneous combustion.

Special Fireworks include all that contain any quantity of red phosphorus, a fulminate, or other high explosive sensitive to shock or friction; or that contain units of such size that the explosion of one while being handled would produce a serious injury; or that require a special appliance or tool, mortar, holder, etc., for their safe use: or that are designed for ignition by shock or friction. Examples are giant firecrackers, bombs and salutes (not high explosives), toy torpedoes and caps, ammunition pellets fired in a special holder, railway torpedoes, etc.

Spirits of Nitrous Ether. (See Ethyl Nitrite.)

Stain, Furniture or Leather, may contain inflammable liquids of such nature as to give flash point of 80° F. or below.

Spirits of Turpentine. (See Turpentine.)

Strontia may be term used to designate strontium nitrate.

Strontium Nitrate consists of a heavy white crystalline salt, which is a strong oxidizing agent. Its principal use is making a red fire in fireworks. It is commonly shipped in barrels, and boxes, and when so packed is not classed as an oxidizing material by the I. C. C. Regulations.

Sulphuric Acid. (See Acid, Sulphuric.)

Sulphur Dioxide is the gas formed by burning sulphur on iron pyrites in air. It has the well known irritating and suffocating odor of burning sulphur. The liquefied gas is shipped in iron or steel cylinders. It is entirely non-inflammable. The pressure at 70° F. is approximately 50 pounds per square inch. It requires a green (gas) label.

Tankage, Dried Blood, is composed of blood from slaughter houses, evaporated to dryness and pulverized. It is used as fertilizer. It is not inflammable.

Tankage, Garbage. (See Garbage Tankage.)

Tankage, N. O. S., consists chiefly of various kinds of slaughter house scraps and offal. The fat and grease are first extracted, and residue is then dried. Tankage of this character is not inflammable, nor liable to spontaneous combustion.

Temperatures. In this pamphlet measurements of temperature have been expressed in Fahrenheit degrees, as that scale is in common every day use throughout the United States and Canada. In technical books, laboratory reports, etc., the Centigrade scale is often used. The following table will serve to change the Centigrade temperature to the corresponding Fahrenheit temperature.

COMPARATIVE TABLE OF THERMOMETERS

1 Fahrenheit degree = 5/9 deg. Cent. = 4/9 deg. Reaumur
1 Centigrade degree = 9/5 deg. Fahr. = 4/5 deg. Reaumur
1 Reaumur degree = 9/4 deg. Fahr. = 5/4 deg. Cent.
Temp. Fahrenheit = 9/5 × temp. C. + 32 deg. = 9/4 R. + 32 deg.
Temp. Centigrade = 5/9 (temp. F. — 32 deg.) = 5/4 R.
Temp. Reaumur = 4/5 temp. C. = 4/9 (F. — 32 deg.)
Freezing point: Reaumur = 0 deg.; Cent. = 0 deg.; Fahr. = 32 deg.
Boiling point: Reaumur = 80 deg.; Cent. = 100 deg.; Fahr. = 212 deg.

Cent.	Fahr.	Reau.	Cent.	Fahr.	Reau.	Cent.	Fahr.	Reau.
—18	0	—14	107	225	86	234	455	187
—15	5	—12	110	230	88	237	460	190
—12	10	—10	113	235	90	240	466	192
—9	16	—7	116	241	93	242	469	194
—7	19	—6	118	244	94	245	475	196
—4	25	—3	121	250	97	248	480	198
—1	30	—1	124	255	99	251	486	201
2	36	2	127	261	102	253	489	202
5	41	4	129	264	103	256	495	205
7	45	6	132	270	106	259	500	207
10	50	8	134	275	107	262	505	210
13	55	10	137	280	110	265	511	212
16	61	13	140	296	112	267	514	214
18	64	14	142	289	114	270	520	216
21	70	17	145	295	116	273	525	218
24	75	19	148	300	118	276	531	221
27	81	22	151	306	121	278	534	222
29	84	23	153	309	122	281	540	225
32	90	26	156	315	125	284	545	227
35	95	28	159	320	127	287	550	230
38	100	30	162	325	130	290	556	232
41	106	33	165	331	132	292	559	234
43	109	34	167	334	134	295	565	236
46	115	37	170	340	136	298	570	238
49	120	39	173	345	138	301	576	241
52	126	42	176	351	141	303	579	242
54	129	43	178	354	142	306	585	245
57	135	46	181	360	145	309	590	247
60	140	48	184	365	147	312	595	250
63	145	50	187	370	150	315	601	252
66	151	53	190	376	152	317	604	254
68	154	54	192	379	154	320	610	256
71	160	57	195	385	156	323	614	258
74	165	59	198	390	158	326	620	261
77	171	62	201	396	161	329	625	263
79	174	63	203	399	162	332	630	266
82	180	66	206	405	165	335	636	268
85	185	68	209	410	167	337	639	270
88	190	70	212	415	170	340	645	272
91	196	73	215	421	172	343	650	274
93	199	75	217	424	174	346	656	277
96	205	77	220	430	176	348	659	278
99	210	79	223	435	178	351	665	281
102	216	82	226	441	181	354	670	283
104	219	83	228	444	182	357	675	286
			231	450	185	360	681	288

Toluene is a distillate from coal tar. It resembles benzol in odor and appearance, but is somewhat heavier and less volatile. It has a flash test of 55° F. It is classed as an inflammable liquid.

Toluol. (See Toluene.)

Torches, Railroad. (See Fusees.)

Torpedoes, Toy, small paper-covered pellets containing a paper cap containing a small quantity of red phosphorus and chlorate. This cap is surrounded by particles of gravel to produce friction. The paper cap in torpedo is sometimes replaced by a small particle of loose, dry, silver fulminate. Classed as special fireworks. Sometimes these torpedoes owing to undue sensitiveness or improper packing, will explode in mass. Such explosions are rare, and of comparatively slight force.

Torpedoes, Track, consist of hollow tin or fiber discs, filled with a mixture of sulphur, potassium chlorate, and sand or gravel. They are meant to be exploded by weight of locomotive passing over them. Classed as special fireworks.

Trinitro Benzol. This compound when dry is a high explosive, but when wet with not less than 20 per cent water and placed in waterproof containers, may be shipped as inflammable solid, with yellow label.

Trinitro Phenol. (See Trinitro Benzol.)

Trinitrotoluol. (See Trinitro Benzol.)

Turpentine is a clear, colorless liquid of well known characteristic odor. It is obtained by the distillation of the exudation from pine trees. It is used principally in paints and varnishes. It has a flash test of 95° F.

Turpentine Substitutes are usually petroleum distillates, usually having about the same flash test as turpentine, but the flash point may be below 80° F.

Varnish Removers. (See Paint Remover.)

Varnish, N. O. S., may have flash test at 80° F. or below.

Viscoloid. (See Celluloid.)

Whistling Bombs. (See Bombs, Whistling.)

Wood Flour is finely divided wood, which has been reduced to a fine powder, by mechanical means. It is used as an absorbent in dynamite manufacture, and also to a certain extent in paper making. It is readily ignited by sparks, but burns slowly when ignited. It is not considered liable to spontaneous ignition. It is not classed as a hazardous article by the I. C. C. Regulations and is commonly accepted by the steamship companies.

Wood Naphtha. (See Alcohol, Wood.)

Wood Pulp. This term is commonly applied to Wood Flour in the explosives trade. It is more properly applied to the material made by digesting wood with caustic soda, or sulphurous acid. These pulps are felted and baled. They are not used in the explosives business, but in paper manufacture. As regard to hazard wood pulp is approximately the same as wood flour.

Wood Spirits. (See Alcohol, Wood.)

Xylene, or Xylol, is a coal tar distillate similar to toluol, but heavier and less inflammable. It has a flash test of 95° F.

Xylonite. (See Celluloid.)

Zinc Dross. (See Dross, Zinc or Lead.)

Zinc Dust, consists chiefly of finely divided metallic zinc. It is liable to spontaneous ignition if wet. It is classed as an inflammable solid.

Zinc Flue Dust, from some processes is very similar to zinc dust and has the same risks. Other zinc flue dusts consist almost wholly of oxides and are non-hazardous.

COMMON NAMES OF CHEMICAL SUBSTANCES

Aqua Fortis	Nitric Acid
Aqua Regia	Nitro-Muriatic Acid
Blue Vitriol	Sulphate of Copper
Cream of Tartar	Bitartrate of Potassium
Calomel	Chloride of Mercury
Chalk	Carbonate of Calcium
Salt of Tartar	Carbonate of Potassia
Caustic of Potassa	Hydrate of Potassium
Chloroform	Chloride of Gormyle
Common Salt	Chloride of Sodium
Copperas, or Green Vitriol	Sulphate of Iron
Corrosive Sublimate	Bi-chloride of Mercury
Diamond	Pure Carbon
Dry Alum	Sulph. Alum. and Potassium
Epsom Salts	Sulphate of Magnesia
Ethiops Mineral	Black Sulphide of Mercury
Fire Damp	Light Carbureted Hydrogen
Galena	Sulphide of Lead
Glucose	Grape Sugar
Goulard Water	Basic Acetate of Lead
Iron Pyrites	Bisulphide of Iron
Jeweler's Putty	Oxide of Tin
King Yellow	Sulphide of Arsenic
Laughing Gas	Protoxide of Nitrogen
Lime	Oxide of Calcium
Lunar Caustic	Nitrate of Silver
Mosaic Gold	Bisulphide of Tin
Muriate of Lime	Chloride of Calcium
Niter of Saltpeter	Nitrate of Potash
Oil of Vitriol	Sulphuric Acid
Potash	Oxide of Potassium
Red Lead	Oxide of Lead
Rust of Iron	Oxide of Iron
Sal Ammoniac	Muriate of Ammonia
Slacked Lime	Hydrate of Calcium
Soda	Oxide of Sodium
Spirits of Hartshorn	Ammonia
Spirit of Salt	Hydrochloric or Muriatic Acid
Stucco, or Plaster of Paris	Sulphate of Lime
Sugar of Lead	Acetate of Lead
Verdigris	Basic of Acetate
Vermilion	Sulphide of Mercury
Vinegar	Acetic Acid (Diluted)
Volatile Alkali	Ammonia
Water	Oxide of Hydrogen
White Precipitate	Ammoniated Mercury
White Vitriol	Sulphate of Zinc

MANUFACTURING HAZARDS

On examining the danger-producing features, or hazards, as they are commonly designated, of various businesses, it will be found that most of them can be classified as furnaces, driers or kettles. There are many, however, which can hardly be included in any of these groups, and, as they are dissimilar, they will, in the following article, be treated under the general heading "Miscellaneous."

Furnaces

In practically all instances the features of significance here are setting, clearance, stack or chimney and method of heating or fuel used.

By setting is meant the nature of the enclosing walls of the furnace and the manner in which these, as forming the furnace, are set or arranged, as well as the condition in which they may be found.

Clearance refers to the distance of any heated portions of the furnace from woodwork or other fixed inflammable materials, and does not include distance to or proximity of temporary rubbish or other materials, which is a matter of management. Clearance is further analyzable into bottom, side—meaning any one or all four sides—and overhead clearance.

By stack or chimney is meant the enclosure for the flue conveying away the heated gases of combustion, including the breeching or uptake or downtake to such stack or chimney. The construction, location inside or outside or in walls, condition and clearance of stacks or chimneys are the significant features in connection with them.

Method of heating or fuel used refers to the source of heat, and includes coal, coke, wood, gas, gasolene, electricity (as in carbide furnaces), fuel oil, etc., and the conditions under which these may be handled or used. A fuller treatment of these features is given under "Boilers," and will not be repeated elsewhere.

Annealing Ovens.—These are too numerous in kind to receive specific mention. The more common and the general characteristics of the ovens as a class, therefore, will be given. Annealing ovens are primarily and principally for drawing an undesired temper acquired in shaping materials or to prevent brittleness by providing a gradual cooling process.

Plate glass annealing ovens or kilns, as they are called, are large flat ovens heated to about 1100 degrees F., into which the freshly rolled plate of glass is pushed and kept for five days until it has gradually cooled. Inasmuch as the roofs over these ovens are generally low, the heat from open doors may, in time, desiccate the roof timbers; the roof supports are also frequently found in contact with the setting.

Sheet-iron annealing ovens and those in tin-plate rolling mills are small house-like ovens, generally brick and iron-bound, in which the sealed annealing-boxes are placed, the boxes containing stacked sheets of iron rendered too hard by the repeated rolling they have received. Roofs above these are low in some plants; they should be well away from the tops of the ovens, and the surrounding floor should be fireproof, as the annealing boxes are dragged out quite hot.

The bake ovens or annealing ovens in wire mills are for drawing the temper acquired in passing the wire through the dies in the operation of "drawing," or for drying the coils after the scale has been removed from the rods. Generally brick and iron, with no special characteristics.

Annealing ovens for beer bottles or glass bottles, to be used under pressure, differ from leers (q. v.), in that the bottles are stacked in brick, iron-bound ovens and allowed to remain several days.

Malleable castings are annealed by enclosing them in pots or boxes containing red hematite and heating them several days in a brick oven-like furnace.

Assaying Furnaces.—There are several general kinds, for calcination, roasting, reduction, fusion, scorification, cupellation and smelting. If ore be damp, it is calcined to dry it; if it be a sulphide, it must be roasted before charged in the crucible with the fluxes, etc., the object of roasting being to ensure oxidation and the elimination of sulphur, arsenic, antimony, etc. In reduction and fusion the ore is heated with fluxes and reducing agents in a crucible or scorifier. Scorification and cupellation may both be classed as a combination of fusion, roasting and sublimation, the difference being that in the case of cupellation the volatile compounds formed are absorbed by the cupel, while in scorification they form a slag. Smelting in its restricted sense is the reduction of ores, sweepings, metallurgical products, etc., by fusion in a furnace. Calcining and roasting furnaces have shallow fireplaces and, ordinarily, brick bodies bound with iron, cast-iron top plate, removable grate-bars, a hood to carry off fumes and a stack or chimney of brick, iron or clay; the temperature used is not high. Reduction and fusion furnaces are similar to ordinary crucible brass furnaces (q. v.); a high temperature is used. The various furnaces above-mentioned are similar to one or the other of these forms.

Bake Ovens.—Reference is made here to ovens for baking crackers, bread, etc. Modern bakeries generally have large brick ovens with a grate fire at the bottom of a large chamber, in which, above the fire, rotates a sort of ferris wheel, the cars of which are flat pans to carry the crackers, biscuits, etc., to be baked. These ovens have brick-arched ceilings covered with a foot or more of sand, so that top clearance is not so significant as side clearance. The firing pit should be fireproof. The wheel is moved by machinery and so timed in its rotation that baking is accomplished in one complete turn, when the product is removed by paddles. Newly-baked crackers should not be barreled immediately, as they contain sufficient heat to cause trouble. Nor should the cracker coolers and chutes be of wood. Bread bake ovens are generally flat and massively built, so as to retain the heat at an even temperature, and clearance is not so important, although it is well to keep them free. Portable iron ovens are also frequently used for various baking operations in the case of smaller orders, being practically large ovens similar to those in ranges.

Bark Furnaces.—Generally in connection with boilers at tanneries and for burning spent bark. Occasionally they are mere burners, like fireplaces, in which no effort is made to utilize the heat, but as a rule, they are brick and iron furnaces attached to the boiler fronts and fed from the top, the bark being piled on top as it falls from the conveyor. Inasmuch as the bark is damp, this practice and that of piling it against the side setting of the furnaces and boilers are not so objectionable as they would appear.

Barrel Heaters.—Usually the worst feature in cooper shops, not excepting the boiler hazard. Sometimes they are simply open hearths on which the barrels are placed and a fire built inside. Again, they are salamanders on a platform. Yet again they are cylinder-like stoves with the flue at the bottom, or conical-shaped stoves with telescoping flues at the apex, so as to permit the removal of the barrels from about the stoves. Rarely they are gas-heated cylindrical stoves or steam-heated cylinders. Probably, the most objectionable form is the open hearth; the safest, the steam cylinder. Salamanders are not so bad as the open hearth, but nearly, and the other forms are fairly safe when properly arranged. Doubtless, the reasons for these opinions are clear when it is reflected that refuse nearly always strews the floor about such heaters. The floor about heaters for 6 feet or more should be protected.

Bessemer Converters.—Tilting steel, fire-brick-lined furnaces for eliminating the carbon and silicon from pig iron, preparatory to its conversion into steel or ingot iron, by forcing a blast of air through the iron while it is molten. Inasmuch as the blast is powerful, sparks and red-hot cinders are thrown 100 feet or more into the air, and all roofs within reach should be incombustible.

Billet Furnaces.—Reheating furnaces for billets which are blooms of iron or steel drawn into smaller bars. Generally brick, iron-bound. Clearance of both stack and furnace important.

Blacksmith Forges.—These are in general stationary and portable. Practically all portable forges are iron or steel, with attached geared blowers. Stationary forges may be of the portable type or consist of iron or brick bodies into the center of which the blast-hole is built. Occasionally, such forges have wooden box-like bodies; these are objectionable, as a rule. Forges are such simple hazards that the dangers are often overlooked. A few remarks are therefore added. They should not be located near wooden partitions or boxes or other inflammable materials against or into which coals might land when the blast is on. These sometimes smoulder undetected and break out later. Floors which are splintered or in bad repair or with wide cracks between the boards are also objectionable, as well as the presence of openings in sheathing or lath and plaster finish on walls, ceilings or partitions. The fans or blowers supplying the blasts are sometimes run by belts from the floor below, and care should be taken to see that nothing inflammable is underneath the belt-hole. Anvils are also apt to throw scale around even further than the sparks from forge fly ordinarily.

Blast Furnaces.—A type of furnace, consisting of tall structures in which the materials and fuel are mixed together, an air blast introduced near the bottom, and in which fusion of the contents is effected. The principal furnace of the type is used to smelt ore in making pig iron. Formerly they were brick or stone, like huge lime kilns, but nowadays they are tall iron and steel stacks, lined with fire-brick, with loading platforms near the top and tap-holes and tuyeres near the bottom, the tap-holes being for draining off the molten iron and the tuyeres the mouths of the air blasts. A bell or cup-and-cone arrangement closes the top after each charge. The gases pass through a flue in the side into a "down comer" leading to the boilers, "stoves," etc. Explosions, arising from air admitted during charging, are possible, but are guarded against by explosion doors consisting of simple flap-checks. There is also danger of the charge bridging or arching, technically known as "hanging," within the furnace, and then collapsing and bursting the sides or bottom out. There should, therefore, be no inflammable material near the furnace. Owing to the repeated flaring noted at the top of the furnaces during charging, the structures on the loading platform near the charging door should be fireproof. Smaller furnaces of the type are used in smelting lead.

Bloom Furnaces.—For reheating blooms or long slab-like masses of steel or malleable iron from which the slag has been forced by hammer, rolls or squeezer. Clearance of both stack and setting important.

Blow Furnaces.—In window glass factories. Large reheating furnaces for heating the glass cylinder as it is blown. Generally brick and iron-bound, and burning coke, coal, gas or fuel oil. In front of the round openings into which the blower holds the cylinder are footpaths generally of wood for the workmen to walk backward and forward upon in swinging the cylinder. A dip pit is under these paths and generally communicates with a basement. Aside from the regular furnace hazard is the danger of charring the wooden footpath, which is necessarily wood, as the cylinder strikes against it from time to time, and stone and iron would fracture the glass.

Bluing Ovens.—Generally small brick ovens, practically for tempering, used in giving the blue finish to gun barrels, revolvers, etc. No special comments necessary.

Boilers.—The hazard of these is mainly due to piling lumber or small pieces of wood on top of the boilers to dry, to direct exposure of beams, joists, partition or other woodwork by the breeching or stack, to back-drafts, or to the ignition of piles or trains of shavings in front of the furnace.

The objection to drying inflammable materials over boilers arises from the fact that unequal expansion of the boiler itself, its archings or its setting, causes cracks in the setting or arching. Where shavings are used sparks will fly out quite freely, and even hot air will escape from the crevices sufficiently to char and ignite wood near, laid there to be dried out. This is the main danger at this point. The fine dust which settles on top of boilers will in some instances smoulder and hold fire like punk, and an additional danger arises here. The writer has conducted many experiments with such dust. While most dust of this description will not ignite easily when laid, some of a fluffy, splintery, fibrous nature will, and care should be taken to keep the tops of boilers free from it. The dust from soft wood removed by sanders, especially by side abrasion, is particularly apt to smoulder or flame up. Sand and ashes are sometimes used to cover the arching, but these are not safeguards enough to warrant the practice of drying wood, etc., on top of the boiler since they set in time, and fissures and crevices form in them also.

Back-drafts are due mainly to the accumulation of unignited gas in the furnace or flue from temporary choking, caused by wind, sudden atmospheric changes, etc., and may send sparks and coals from the furnace into the fire room. For this reason the door of the shavings vault should not be opposite that of the furnace. Neither should any communication with the main building be opposite the furnace, even when provided with a fire-door, as the latter might be opened at the time of a back-draft. Back-drafts, however, are not of frequent occurrence.

The breeching, unless lined with brick, is a serious exposure to woodwork even two or three feet away, and for this reason proper precaution should be taken to protect any woodwork so exposed. Soot accumulations sometimes cause over-heating, and even where refuse alone is used as fuel the crowding of a boiler may overheat the breeching. Unlined iron stacks may also become a source of danger for very similar reasons. As a rule, however, such stacks are not as serious hazards as the breeching, which is too frequently ignored as a hazard. Stacks should be well ventilated and provided with hoods and thimbles where they pass through the roof. Joists should not be let into brick stacks unless the latter are very heavy, and it is just as well then to be on the safe side by providing headers about the stacks to carry floor beams or joists.

Trains of shavings are sometimes left by a careless fireman from the furnace to the open door of the vault. These may be ignited and start a fire. Again, shavings from the dust collector are occasionally allowed to fall through the air from the bottom of the collector to the floor in front of the boiler, where they are shoveled into the furnace. The objection to this practice need not be pointed out. A remote danger is the explosion of dust in the feed flues where shavings are blown directly to the boilers. This danger is practically obviated by the intervention of dust collectors, back-check flaps and automatic regulators. In general, it may be said that the boiler hazard is most serious when soft wood is worked and merely nominal where wet wood (as in butter-dish factories) is handled. Where refuse is used for fuel, spark-arresters should be provided for the stack, as the risk or its neighbors often suffer loss from flying sparks. Sparks are particularly noticeable when there is a forced draft, unless the draft is produced by exhausting steam into the stack.

Brass Furnaces.—As a rule, cylindrical iron, fire-brick-lined furnaces containing coke fires upon which rest the crucibles holding the brass to be melted. Provided with covers. Coal is nowadays used as fuel, also, but needs more blast to get the desired heat. Stacks of such furnaces are very hot and usually too light. The furnaces, unless set in the ground, should be suspended in iron pits clear of all woodwork, as side and overhead exposures are intense.

Brazing Forges.—Brazing is an operation similar to soldering on a large scale, the metal corresponding to the solder having, however, a higher degree of fusibility than the latter. It is really the welding of two metals, alike or dissimilar, to a third between them. Ordinarily some modification of a Bunsen burner is used, but blacksmith forges (q. v.) are frequently used. Many brazing apparatus use the Bunsen burner or blowpipe principle, the flames impinging against the work as it rests on a bed of coke, charcoal, stones or fire-bricks to give the heat a cumulative effect. Such beddings should never rest upon wood-work, as they heat through gradually and set fire to the charred wood-work. It is impracticable to detail at this point the various methods of supplying heat. See "Gasolene," "Fuel-oil," etc.

Busheling Stoves.—Used for heating flat-irons, tailors' irons, etc., in hat, overall, shirt and clothing factories and similar risks. They are ordinary stoves with polygonal bodies, against the many faces of which the irons are allowed to rest while being heated. Hazard that of large overheated stoves. See "Slug Heaters."

Calciners.—These are of kiln type and for expelling moisture. Lime kilns, calcination furnaces, plaster kilns, etc., are examples. Generally heavily built of brick or stone. Well to prevent woodwork from coming in contact with setting, however, as fissures may form.

Candy Furnaces.—Usually cylindrical iron, fire-brick-lined and having concentric annular lids for varying-sized kettles. Coke or hard coal fires generally used; sometimes gas and artificial coals. Chimneys very hot and frequently too thin. Brick or cement platform with raised edges should surround furnaces, and hood be provided overhead if ceiling be low, in case of accident from boiling over. Used in candy kitchens and factories, bakeries, for syrup boiling, in extract works, in fruit-cleaning establishments, etc.

Carbide Furnaces.—Electric furnace for making calcium carbide from lime and coke by fusion. Intense heat internally, but furnaces are heavily built and usual furnace hazard mild.

Carbon Point Furnaces.—For baking lamp carbons. Intense heat used and clearance and stack important.

Coffee Roasters.—Name signifies use. Generally brick with rotating horizontal metal cylinders set in them for tumbling coffee as it is roasted. Coal, coke or gas fuel generally used. Some danger of roasted-out gas igniting. Clearance all sides and stack important. No wooden spouts should be allowed near, and coffee should, after roasting, be cooled in iron receptacles, as it retains sufficient heat to char wood. Preferably ceiling and floor of roaster room should be fireproof.

Coke Ovens.—For roasting gas out of soft coal in the manufacture of coke. Generally stone and arranged in batteries many hundred feet long. Seldom under cover.

Cupolas.—Smaller blast furnaces used in foundries for remelting iron preparatory to casting. Generally iron, fire-brick-lined stacks, with charging door in the side, air blast and tap-hole near bottom and dumping bottom. They emit a shower during a melt, especially when the charge runs low. Should have good clearance at roof and charging floor, as well as at the "dump" or place where the refuse slag and cinders are allowed to fall from the bottom after a run. The "dump" is the worst feature in connection with cupolas, especially large ones such as those in car-wheel foundries, when the heat from the pile of cinders and slag is so intense that it may ignite woodwork 30 feet away. Small hose should always be provided at cupolas, and the cupola house itself, if not cut off, should preferably be fireproof.

Crematories.—Reference is made more particularly to garbage crematories. Those for cremating the dead are generally gas-heated and in elaborately fireproof surroundings. Garbage and dead animal burners are generally box-shaped brick furnaces, bound with iron, with charging doors in the top which is level with the receiving floor and grates underneath. An effort is made to make them self-sustaining in the matter of fuel, gas, coke, coal and fuel oil being used to assist the cremation. Ceilings above furnace and charging doors should be high and receiving floor should not, unless fireproof, be in contact with setting. Small garbage crematories are in use in the back yards, in some cities, these being small brick enclosures without tops.

Flattening Ovens.—Used in window glass factories to roll out or flatten the glass after the glass cylinder has been seamed or cracked along its length. A combination reheating and annealing oven, the reheating part containing a circular rotating table upon which the glass is flattened by means of wooden blocks on the ends of pokers or rods. Roofs over these generally low, and there is a tendency to let roof timbers rest on the setting. See "Leers."

Galvanizing Furnaces.—Generally long, low, brick melting furnaces, with the fire under an open pot containing the zinc or alloy. For galvanizing or coating with zinc, alloy, pipe, wire, hooks, eyebolts, velocipede wheels, etc. Stack generally most important feature, as clearance and setting are apt to be good. Various fuels used.

Gas Producers.—Reference is made more particularly to those producers making fuel gas from soft coal by roasting it, the gas being conveyed hot directly to the furnaces by means of large flues. In these producers advantage is taken of the fact that carbon dioxide is reduced to carbon monoxide by red-hot carbon. Ordinarily, the producers consist of deep grates into which the fuel is fed from above, the air entering below the charge. There are several makes of producers which are generally iron, fire-brick-lined, and in a two-story house, the second story being for charging purposes and the first for firing. If adjoining or exposing main buildings, the producer house should be entirely fireproof, as fires are frequent from direct exposure, puffs or back-drafts, dust explosions and spontaneous combustion of soft coal.

Gas Stacks and Retorts.—Retorts are used in the manufacture of coal gas. They are cylindrical receivers horizontally placed, closed at one end and sealed at the other by a hinged door. They are arranged in tiers like the tubes of a boiler, and enclosed in a brick setting somewhat similar to that of boilers, with a coke fire under them. The retorts are filled with bituminous coal, sometimes mixed with cannel coal, from which gas is roasted or distilled. This gas passes by its own expansion through a riser at the front end which ascends and turns downward into the first seal or hydraulic main, as it is called.

The dangers in connection with retorts may be several. Ordinarily they are not serious in properly constructed plants. There is the ordinary furnace hazard. In withdrawing the charge after a "run," there is a possibility of its setting fire to any woodwork with which it might come in contact or be near, and the building should have an incombustible floor and walls. When the retort doors are opened there is a mild explosion of the already heated and expanded residue gas inside mixed with the newly admitted air, resulting in some soot which lodges on the walls and roof, as well as small sparks or pieces of soot, from the concussion, being sent upward. Soot is also produced from the smoking at the retort doors when the riser to the hydraulic main becomes choked until, in time, the rafters become coated with flaky soot which the above-mentioned sparks, or those of extraneous origin, may ignite. It is evident, then, that the retort house roof should be incombustible. Another danger shared between the retorts and hydraulic main is from leakage in the seal of the latter which may result in the admission of air from a back pressure into any retort which should happen to be opened for the purpose of recharging. Such accidents have occurred, resulting in the wreckage of the hydraulic main, the top of the retorts and the roof.

Stacks are used in the manufacture of water gas. They are the generator, carburetter, superheater and combined stacks. In the separate stack system the generator is an iron cupola or stack lined with fire-brick, and containing a deep bed of coke fire into which steam is injected. Before the "run" is begun, however, an air blast from a Sturtevant or other fan heats the fire up to the desired temperature. It is then shut off and the steam admitted. The temperature, about 1600 degrees F., disintegrates the steam into its component elements, oxygen and hydrogen, the former uniting with the coke and producing carbonic oxide, and the latter remaining free. These two gases pass over in about equal volumes to the carburetter through what would otherwise be the smoke flue of the generator.

In this system the carburetter is a similarly built furnace to the generator except that it contains a checker-work of heated bricks against which the crude oil is sprayed. This oil is first heated by being led up through the delivery main of the superheater, and is drawn from tanks by means of small steam pumps. The heated bricks vaporize the oil which mingles with the hydrogen and carbonic oxide from the generator, and all pass on to the superheater which makes them a fixed gas to prevent subsequent condensation. There is something of the furnace hazard in the carburetter, but it is slight. A more serious danger is the accidental admission of air, which can come through the blower pipe, as stated, or through the peep-holes provided for the operator if carelessly manipulated or injured. The peep-holes are iron pipes with two shut-off valves, the outer having a center of glass, or one shut-off valve and a fixed glass eye-piece. Evidently, the breakage of the eye-piece would result in an accident which might fire the building.

The superheater in the separate stack system is a furnace similar to the carburetter, without the oil injectors, and provided with the final smoke-flue for the system (when the blast is on), which flue is covered with a lid when the apparatus is making a "run." After a "run" the lid is lifted, the air blast started, and any remaining gas blown out through the flue, clearing the apparatus for a new "run." The superheater is provided with a water-seal which prevents the gas, during a "run," from returning to the superheater. The superheater is also provided with peep-holes, the hazard from which has been indicated, and there is considerable of the furnace hazard, but the features most likely to result in fire are the "roaring" at the top of the stack when the blast is put on and the ignition of the mingled gas and air at that point. The "roaring," so-called, makes the ventilator above red-hot, and the combustion of the gas and air envelops the whole roof with flames. Evidently, the building must be entirely iron and brick. The roaring is similar to that of a foundry cupola and from very much the same cause. The ignition of the residue gas and the air at the top of the superheater is intentional, being effected by a pilot-light at the point designed to burn any escaping gas. It is, however, none the less likely to burn the roof if it is wood. Leakage of the oil pipe in the delivery main may also cause trouble, but it would probably be local.

In the combined stack system each stack is arranged with a deep bed of coke fire at the bottom, with several skeleton arches above, each arch carrying its quota of checker-bricks against which the crude oil impinges. Each stack has also a blow-off flue and lid.

The hazards are similar to those in the separate system, except that they are rather more marked, owing to the fact that the admission of air is apt to result in worse explosions. The oil is also heated by a jacket of steam instead of being passed through the pipe inside of a delivery main. Repairs are thus more easily made and the exact condition of the oil system known. The arrangement of glower valves is more complicated, and therefore human error is likely to play a greater part in accidents.

Glory Holes.—Small reheating furnaces found only in bottle factories, for reheating the necks preparatory to shaping the bead upon it. Formerly heated by coke and coal fires, the ashes of which fell through the eye and could expose the timbers of the floor underneath. Now heated by gas or fuel oil. Generally well away from walls and surrounding the melting furnace proper, the room containing which has a high ceiling. Ordinarily, they are small fire-brick, iron-bound furnaces, similar to large soldering-iron heaters, set on iron legs.

Hearths.—A type of furnace used principally in metallurgical work and steel and iron mills, and consisting of shallow and more or less open fireplaces, in which the materials and fuel are mixed, a blast of air supplied and the atmosphere made more or less oxidizing by varying the amount of air supplied. Generally brick and iron. Clearance important.

Hearths.—Reference is not made to the type bearing this name, but to fireplaces and barrel hearths. Chimneys for these should be double brick, with ample throats. The floor of the fireplace should extend well in front of the fire, and the space under the fire or grate, if any, should be built on brick or cement arches. There is always danger, with wood fuel, of sparks flying out into a room.

Heating Furnaces.—Furnaces classifiable thus are almost innumerable. The principal are heating furnaces for sheet iron in cut nail works; rods in nut and bolt works; billets and blooms in steel and iron works; rods, bars and blocks in forge and blacksmith shops; fagots in rolling mills; trunnions, axles, ordnance, etc., in ordnance foundries and forge shops, and for various parts in straight metal and mixed metal and wood-workers.

Heating Furnaces (for buildings).—These are of the general kinds—steam, hot air and hot water. Hot air furnaces are of two kinds—those supplying the hot air to the rooms through flues and those heating the rooms by circulating the hot air through radiators. Hot water heating is accomplished by circulating hot water through radiators similar to steam radiators. In all systems a furnace is required, and this is generally iron-jacketed or set in brick. Top clearance to joists and side clearance to wooden bins or partitions are generally important. Smoke flue should also have good clearance and enter chimney horizontally. Hot water and steam pipes should not come in contact with wood, as even hot water pipes char wood, and the lower the temperature at which wood is charred the easier it ignites. Hot air flues should be double in partitions and cold air intake flues should be iron for several feet away from furnace. Ashes should be kept in metal receptacles and not mixed with papers and rubbish in wooden boxes or barrels.

Kilns.—These are generally for expelling moisture or chemical constituents by heating. They are nearly always heavily built of brick or stone, but are sometimes metal and lined with fire-bricks. Lime kilns are of two types, continuous and periodic, both being subdivided into short and long-flame kilns. Short-flame kilns have alternate layers of fuel and long-flame kilns burn the fuel on a grate, the gases only coming in contact with the limestone. Gypsum kilns in plate glass works, in which the gypsum is calcined in making plaster of paris for setting the glass on the polishing wheels, cement kilns and rock-burning kilns in plaster mills, are all similar to lime kilns. Plaster kilns in plate glass works, for reclaiming the plaster of paris after it has been used, are rather furnaces than kilns, being brick and iron-bound. Calcining operations in all kinds of metallurgical work are frequently carried on in kilns. Clearance the main feature in all.

Knobbing Furnaces.—Small bloomery furnaces. Much used formerly in steel manufacture and then using charcoal fuel. Brick, iron-bound. Roofs above were low, dried out and subject to frequent fires from sparks rising.

Lead Furnaces.—In smelting lead there are four general kinds of furnaces: reverberatory, blast and slag furnaces, and melting-pots for desilverizing. The reverberatory and blast furnaces are of the usual construction, the latter resembling a foundry cupola; the slag furnace or hearth is a sort of blast furnace of brick and iron construction, for treating rich slags obtained in smelting in the reverberatory furnaces, and the melting-pots are huge iron kettles set on brick foundations, with the fire underneath.

Leers.—Low brick annealing furnaces for bottles, table ware, etc. Ordinarily they consist of a tunnel-like oven with a fire at one end, a chimney near the middle and an open door at the other. The ware to be annealed is placed upon iron trays and shoved into the heated end of the leer, where a conveyor engages a hook or lug on the trays and draws them through to the cool end where they are removed and the ware packed. Gradual cooling is thus accomplished and brittleness avoided. Roofs above are generally low, but this fact is immaterial unless roof supports are on leer setting. Wooden braces were formerly used and were obviously objectionable. Packing with straw or paper should not be allowed near.

Melting-Pots.—These occur in a great variety of risks for a variety of purposes. Those which may properly be classed as furnaces generally consist of a pot, kettle or basin set on brick foundations, with a gas, coke, oil or coal fire underneath. Some of the more common are lead pots for melting lead in moulding ingots, strip lead, lead castings, etc.; solder-pots in can factories and tin shops, usually for remelting and reclaiming; zinc and tin furnaces for galvanizing, tinning, etc.; stereotype furnaces, for melting type metal in making forms from matrices. They are apt to be set in crowded corners or places, and clearance is an important feature.

Muffle Furnaces.—A type of furnace used in metallurgy and for many purposes in which a chamber is heated by the flames and gases circulating in flues around them. Generally brick and iron-bound.

Pipe-bending Furnaces.—For heating large pipes preparatory to bending. Generally similar to large open blacksmith forges and involving the same hazards on a large scale.

Pitching Apparatus.—In breweries. For coating the interior of kegs with pitch to prevent the tannic acid of the oak staves from affecting the beer. The apparatus generally consists of a superheater for burning out old pitch and a pitch melting-pot. Both vary greatly in construction and details of use. If direct fires are used, the apparatus should be outside or in a fireproof room, as the pitch is apt to boil over.

Portable Forges.—Used for heating rivets, small pieces of metal to be worked, tempering tools, etc. Generally consist of iron basin on iron legs with blower attachment. See "Blacksmith Forges."

Pot Arches.—In glass factories. Brick, iron-bound furnaces for baking the expensive clay glass melting-pots and stones and tweels forming the furnaces. Operated at a high temperature and generally built in a leanto. Inasmuch as the door is frequently opened while the furnace is still hot, the roof overhead will become charred and ignited unless it has full clearance. Side clearance also very important and no wooden braces should be allowed.

Puddling Furnaces.—Reverberatory furnaces for converting pig iron into wrought iron by the expulsion of carbon and impurities. These furnaces are brick, fire-brick-lined and iron-bound. Puddling, in brief, consists of melting down the iron, boiling it and rabbling it (stirring up the charge), firing and balling. The last consists in pushing, by means of rods through holes in the work door, the spongy iron together into a sort of ball, which is then removed and shingled in a hammer or squeezer. Shingling consists of welding the particles of iron together and squeezing out the slag. Clearance, especially of stack, important.

Ranges.—Cooking stoves, generally of a larger size, with oven compartments, broilers, water-backs, etc. Generally cast-iron and sheet-iron. Frequently set too close to wainscoting or partitions and space behind used as catch-all. Wood also piled behind to dry in many instances. Both are bad practices. Hotel ranges frequently have large iron hoods above them to carry off odors and smoke from broilers, etc., and the flues from these hoods should be clear of woodwork, as they often burn out from the greasy accumulations, and bad fires have resulted. Coal or wood ranges should have sheet metal in front.

Reduction Furnaces.—See "Assaying Furnaces."

Refuse Burners.—In connection with sawmills, refuse is burned in pits, piles or furnaces, especially built for the purpose. The pits or piles should evidently be located at a safe distance from the mill and lumber yards, as the wind carries the sparks and small brands surprisingly far. Two hundred feet square clearance is frequently required, but this distance is by no means a guaranty of safety, especially if refuse be burned in huge piles, to which it is sent on conveyors or by hand. Such piles are sometimes seen burning continuously at the end of a long conveyor, which drops the refuse on the heap from a height of 30 to 40 feet. It is hardly necessary to mention that these piles are a serious menace to surrounding property.

A regular slab burner is often found quite near the mill, sometimes within 15 or 20 feet. It consists of a cylindrical furnace of brick or iron, lined with brick, with a dome-shaped wire screen spark-arrester at the top. They run about 10 to 20 feet in diameter and 30 to 60 feet in height. An opening in the side about 20 feet from the ground admits the refuse which is brought to the burner by a drag-conveyor. These are much safer than pit or pile burners, but may start fires. It is possible for a coal of fire or a brand to be carried back into the mill on the return portion of the conveyor. The spark-arresters become worn, allowing sparks to escape, and sparks sometimes issue from the lower doors or cracks above them.

In connection with broom factories, small brick furnaces are used to burn unavailable refuse. They are frequently too close to buildings and surrounded by broom straw.

Regenerative Furnaces.—A type of furnace for many uses, in which the waste heat is employed for heating the air, or air and gas, supplied to the furnaces. Most important is steel and iron plants. The regenerative feature may be applied to other types, as the reverberatory, the famous Siemen's furnace being a regenerative reverberatory furnace. They are generally brick and iron, with compartments and chambers for the waste gases. Generally in fireproof surroundings.

Retorts.—Of various forms and for a multiplicity of uses. Where of the furnace type, they generally consist of a closed vessel of iron, glass or stoneware set on a brick foundation or enclosed in brick, with the fire underneath. Used in coal gas works, in which they are cylindrical iron chambers enclosed in brick walls; in nitric acid plants, in which they are stoneware jugs set on brick furnaces; and in metallurgical operations, in which they are iron vessels fixed in brick work and heated. Explosion hazard in some cases, due to air and gas inside becoming mixed and ignited. Otherwise, ordinary furnace hazards prevail.

Reverberatory Furnaces.—A type of furnace finding many applications, in which the fuel is burnt in a separate part of the chamber, the flame and hot gases only coming in contact with the material treated. Used extensively in steel and iron mills and smelting-plants. Generally brick and iron and in fireproof surroundings. If not, clearance of both furnace and stack important.

Rivet Forges.—Either portable forges (q. v.) or small heating furnaces for heating rivets in bridge, structural iron, boiler, iron tank, ship building, etc., works.

Rouge Ovens.—In plate glass works, for roasting copperas in the manufacture of buffing rouge for use in polishing. Generally flat, brick furnaces.

Salamanders.—Stoves with open tops, no flues and generally raised on three iron legs. Used for heating purposes in foundries, rolling mills, etc., where ceilings are high; also for drying out brewers' vats preparatory to varnishing, for drying new plastering in buildings, for taking chill off foundry sand, etc. Sometimes used in place of forges for heating small work and as stove in barrel-heating. Coke or charcoal the usual fuel; sometimes wood. They should have fixed pans under the grates and be used with great care in any environment containing combustibles.

Slug Heaters.—Stoves or furnaces for heating the removable iron slug used in one form of tailors' irons. Generally coke or coal-fired, brick-heating furnaces. Frequently without sufficient clearance, and, owing to frequent tramping, floors about are apt to be worn. Found in connection with hat, overall, shirt and clothing factories.

Stalls.—A type of calcining furnace taking its name from its general appearance, in which the materials are mixed with fuel. Free access of air is permitted and no fusion takes place. Ordinarily, the furnace consists of two rows of brick compartments with a chamber between, each compartment having the top and outer side open, giving the appearance of horse-stalls. These open places are loosely covered during the operation. Reguli and mattes are often calcined in stalls. There should be plenty of overhead clearance.

Stereotype Furnaces.—For melting the type metal used in casting forms from the pulp matrices in large printing establishments. Generally cylindrical iron, fire-brick-lined furnaces, similar to large candy furnaces with the lead pot set in the top. Frequently set in close quarters.

Stills (direct-heated).—Rare nowadays for distilling spirits. Steam still used more frequently. Direct-heated stills are found in small plants and are very objectionable, owing to the danger of explosion. Furnace hazard normal otherwise, the copper or other metal still being set on an ordinary brick furnace. Platinum stills used in concentrating sulphuric acid are direct-heated, but no inflammable vapors are given off; these stills are very valuable, however, and easily damaged by falling lead from towers or chambers, in case of fire, heated lead and platinum forming an amalgam.

Stoves.—Reference is made to heating stoves, laundry stoves, cook stoves, etc. Their construction is familiar. Their hazards consist of the direct exposure of inflammable material by the stove itself or its flue, the emanation of sparks from the grate or open door or from crevices in the stove or flue and the escape of soot or sparks past possibly ill-fitting collars or thimbles at the entry of the flue into the chimney. In general, wood stoves are the most hazardous, and all stoves, except those using gas, should be set on metal or other protection ample in area; no stovepipes should enter a chimney or tile flue vertically, and chimneys should preferably be built from the ground and not rest on side brackets, stirrups or attic floors. Stovepipes should never pass through blind attics or other concealed spaces, and ventilated thimbles should protect them at all partitions.

Stoves, Hot Blast.—For utilizing the heated waste gases from blast furnaces in warming up the air furnishing the blast. They are variously constructed of brick or iron-lined with brick, with checker-work or flues inside for the cold air to pass through and heated by the waste gases referred to. Such stoves are huge affairs, generally detached from any buildings.

Tempering Ovens.—Of all shapes and sizes, generally brick or iron-bound brick and lined with fire-brick. For tempering tools, steel, parts, etc. Many articles, such as files, are tempered by thrusting them first into a pot of melted lead and then into oil or water or other bath.

Tinners' Furnaces.—Reference is made to all soldering iron heaters. The old style and still used furnace or fire-pot is a small vertical sheet-iron cylinder stove, set on a pan and using charcoal fuel; commonly used by plumbers and roofers and either portable or stationary. Many fires caused by leaving them alone in rubbishy surroundings, the wind or drafts frequently causing them to flare up. Later fire-pots use gas, oil or gasolene flames, and are iron boxes lined with fire-brick, with an apron in front on which to rest the soldering-iron. These should be on iron legs, if inside, and used preferably on iron tables. The use inside of those having gasolene receivers or tanks attached should be discouraged, the gasolene being supplied to the burners, and the blast furnished by air under pressure in the receiver. Such portable devices are subject to hard usage and become leaky.

Tinning Furnaces.—In tin plate works the sheet-iron is passed through a tank of palm oil and then through a large kettle being set on a low brick furnace. The oil sometimes becomes fired and roofs above such apparatus should be high or fireproof and the floor about incombustible.

Tire Furnaces.—For setting tires. In ordinary blacksmith shops a wood fire may be built in the yard about the tire to be shrunk. In some, a cabinet-like oven is provided for heating the tire, the object of heating being to expand the tire so that it will fit over the rim of the wheel which is made a little larger than the interior diameter of the tire when it is cool; as the tire cools, the rim is pulled tightly down upon the spokes and the wheel stiffened. The wood fires referred to should be well away from any buildings.

Wind Furnaces.—A type of furnace consisting of deep fireplaces, with grates at the bottom and flue openings at the top, for heating crucibles, etc. Used for many purposes, but principally in metallurgical work.

Drying and Driers

In driers of all kinds the principal features to be considered are the construction and method of heating. Construction is intended to include all matters of arrangement. Frequently, as in woodworkers, the location of the device is important. To save repetition, it may be well to state that all steam-pipes, direct or exhaust, may cause fire, the steam-pipe hazard being due to the charring and subsequent ignition of the inflammable material. Jets of hot air may also cause fire, in blower systems, even where the jets are of low temperature, the reason for this being obscure.

Board Drying.—In knitting mills. Underwear after washing is drawn over board forms which are suspended by hooks from the ceiling or racks above them, and the room heated by hot air or steam-pipes. Hosiery and knit gloves and mittens are dried similarly.

Bone Drying.—In packing plants, bones, after being washed, are dried on open steam-coils a foot or more above the floor or in specially constructed boxes or rooms, generally of wood. Wooden-slatted trays holding the bones sometimes rest on the steam-pipes, the practice being objectionable. Modern plants build these dry-rooms fireproof.

Bone-black Kilns.—The decolorizing and clarifying properties of bone-black are restored by reburning in retorts heated by furnaces which are usually set in brick and iron-bound. These should be located in fireproof buildings, as there is not only a bad furnace hazard but a great deal of fine dust present. The elevators for the bone-black should also be preferably of iron and arranged so as to be self-cleaning. Preliminary heaters are located above the kilns in some instances, utilizing the hot gases from the furnaces. They are used to dry the bone-black before it passes into the retorts. Modern plants have separately constructed and arranged kiln houses, but should it happen by any chance that the kiln house was of ordinary construction and not cut off, it should be regarded as a prohibitive feature.

Brick Kilns.—These are in general clamps and permanent kilns. Clamps are kilns of the up-draft type, the walls of which are built up at each fire or run and torn down when the bricks within have been burned. They are generally roofed over with boards, also of a more or less temporary nature, but are sometimes erected in regular sheds. The fireplaces are built at the bottom on each side. Sheds are apt to be badly exposed by the kiln tops. Some continuous kilns are partially temporary, continuous kilns being those in which the firing is done in one part while the stacking goes on in another, the operations succeeding each other around the kiln.

Permanent kilns are substantially built of brick and iron-bound, and are either of the down-draft or up-draft type. They are generally not under cover, although sheds similar to the above may be built over them or over the fireplaces, and occasionally they are found inside buildings. Clearance and method of heating are the most important features, oil, gas, coal and coke being used as fuel. The fireplaces are arranged as above.

Terra cotta, terra cotta lumber, tiles, drain-pipes, sewer pipes, etc., are burned in similar kilns.

Brick Pan-Driers.—Flat brick furnaces, the top being like a floor on which green bricks are stacked to dry. Sand or other stock is also sometimes dried on such a floor.

Brick Tunnel-Driers.—Wooden or brick driers for green bricks built in the form of tunnels, into which the bricks are pushed on trucks or racks. Generally steam-heated.

Butterworth Driers.—A drier in textile mills in which the stock is made to pass backword and forward between flat coils of steam-pipes one above another. Several other driers of the same general type. If wooden enclosure, rather objectionable. All should be easily cleanable.

Calendars.—Steam-heated rolls or cans through which paper, cloth, rubber-covered cloth, etc., are passed to be heated and smoothed. Used in super-calendering paper, making gossamer, etc.

Can Driers.—A type of drier in which the stock is wound on or laid over or passes over and between can-like cylinders heated inside by steam or hot water. Used in slashers, paper engines, pasteboard machines, corrugated strawboard packing machines, etc.

Candy Starch or Dry-Rooms.—Generally frame, steam or hot air heated enclosures containing the moulded candy, in wooden racks, to be dried. Sometimes built fireproof, but rarely. Explosion hazard present on account of starch in mould, and no open lights should be used inside or near the rooms. Pipes also become very dusty.

Caul or Dry Boxes or Heaters.—These are small box-like warming and drying ovens used in preparing stock to be glued, and ranging from 1 to 2 feet on a side to 15 or 20 feet long by 4 to 6 feet in width or height. They are, if anything, even more likely to start a fire than kilns, since equal care is not taken in keeping them clean. A fire in one is more accessible, however, and lining with metal reduces the hazard considerably. The steam-pipes should be well collared where they enter and leave the boxes. A particularly objectionable form of dry-box is that sometimes found in musical instrument works, where several turns of a stovepipe inside supply the heat. Defective joints or overheating would play havoc. It may be well to emphasize the objection to caul or dry boxes, as these hazards are frequently underestimated. Certain forms are opened at the top and difficult to clean. Even when lined with tin, therefore, there is a chance for smouldering to occur and break out after hours. Not infrequently wood is left in them overnight, and as they are usually located where a fire once started will spread rapidly, they should be watched carefully. The tin lining, while it reduces the hazard, is not entirely effective in preventing a fire. Other forms have objections that will occur to any one after a little thought. The best form, and one which should be regarded as standard, is that in which the top, sides and ends are iron, with the steam-pipes on iron supports about 6 inches above the lower edges of the sides forming the only bottom, the whole apparatus resting upon iron legs 2 or 3 feet long. With this arrangement, the box is self-cleaning, since there is no bottom, and the hot air, being lighter than the surrounding air, will remain in the box above the pipes. If iron be too expensive, frame boxes built this way are much more desirable than any other.

Chipped Glass Glue Dry-Rooms.—Chipped glass is made by first sanding the surface and then applying a stiff glue which on drying curls up and tears off the surface of the glass, producing the fern-like tracery characteristic of chipped glass. The drying is assisted by gentle steam heat in frame compartments.

Core Ovens.—For drying the cores used in castings. Generally large brick ovens set on the ground, with brick and iron ceilings, iron doors at the entrance and a coke fire inside. The flue or chimney of this type is generally at the far end from the fire, so that the gases and heat will traverse the interior. Another form is an iron oven with trays to carry the cores, sometimes steam-heated, and again set on a stove. Mild furnace hazard in either kind.

Dish Warmers.—Also used as driers. Found in hotels and restaurants and generally consisting of iron steam-heated closets or ovens. Steam-pipe hazards.

Dry Lofts.—In some kinds of oilcloth works large hanging rooms heated by steam-pipes are used, involving the steam-pipe hazard and that of explosion from the volatile ingredients used in making the oilcloth and a serious hazard. Ground rubber is also seasoned or dried in attics or lofts heated by steam-pipes, generally with a mild temperature. Tacking lofts in tanneries are similar to the last, the leather or skins being stretched on frames which are hung from hooks on the bottom of joists or racks built below the joists for the purpose; hot air is sometimes used; hazard mild, as a rule. In some tanneries the tacking frames are piled one above another in front of hot-air pipe openings.

Emery Driers.—In plate glass and other factories where polishing emery is reclaimed. Generally metal pans set over steam-pipes or stoves.

Feed Driers.—For drying refuse from corn-starch works, breweries, distilleries, etc. Horizontal, rotating iron cylinders, as a rule, steam-heated. Sometimes set on iron legs and sometimes in brickwork. Furnace heat often used, coke, coal, gas or fuel oil supplying the heat. Stock is fed in one end and gravitates to the other, falling to the floor or into a conveyor or elevator boot. Clearance and manner of heating important. No wooden spouting nor partitions should be in contact with setting. Direct-heated driers should be in fireproof surroundings or in a section well cut off.

Fertilizer Driers.—Used for drying blood and tankage in packing plants and tankage in garbage reduction works or similar risks. Generally consist of one or more slightly inclined, rotating iron cylinders set in brick and heated by direct fires or steam. Some types are entirely iron, with a lagging of asbestos and set on iron legs. The tankage is picked by hand or machines and shoveled into hoppers leading to the cylinders, in which it is tumbled and from which it emanates in a dry state. It is allowed to fall upon the floor or into the buckets of an elevator. The surroundings are dusty and woodwork is often too close to the setting. A bad feature inside, as a rule.

Fruit Driers or Evaporators.—Generally racks, containing screen-like trays for the fruit, arranged in a room or compartment warmed by hot air or steam-pipes.

Glue Dry-Rooms.—In glue factories the glue is brought from the chill room, sliced up and placed on wire screens with wooden frames. These are piled one upon another on trucks and pushed into long, low, tunnel-like compartments, generally frame and heated by hot air or steam-pipes.

Grain-Driers.—These are of three general kinds—direct-heated rotaries, steam-heated rotaries and stationary driers, heated by steam coils or by air from furnaces or blown through steam-coils. The first are seldom found. Steam-heated rotaries are wooden or iron drums, slightly inclined, into which the grain is admitted and tumbled over steam-coils as it passes through. Hazard that of steam-pipes. Should be constructed so as to be readily cleaned and precautions taken to see that fires in them could not spread through the spouting.

Stationary driers in which the grain rests upon the steam-pipes as a grid are objectionable; these are rare.

A stationary drier, such as is used in oatmeal mills and in other risks for similar purposes, consists of circular pans, one above another, with steam-pipes under each pan. The grain is admitted to the top pan, where it is stirred and pushed along by revolving paddles which gradually work it inward until it reaches an opening near the center through which it falls to the pan below. Here another set of paddles pushes it and tumbles it outward until it falls off the outer edge to the pan below. This operation is repeated through the whole series of pans until the grain has passed through the apparatus and is removed by conveyors. Fans may or may not be provided to remove the moisture which is driven off. Cooling may be done on unheated pans below the heated ones, or separately. There is a steam-pipe hazard in connection with these, and fine particles which the paddles do not touch may remain and become charred, finally causing trouble. Aside from the actual contact of the heating pipes with combustible material, and the last-mentioned feature, which is a matter of care, the hazard of driers of this type is small. They should not be enclosed in wood, however, as the wood becomes desiccated and is readily ignitible in case small fires start on the pans.

Stationary driers, in which the grain is run in and remains quiet while hot air is blown through it from steam coils, are practically the only ones in use nowadays, and will receive more detailed mention. Most of them work on the same principle, the main difference between them being in the mechanical arrangements for holding the grain so that it will be evenly dried or conditioned. Most of them have ducts running through the grain, into which hot air is forced and escapes through the grain, or the grain is columned and the air blown through the walls of the columns. The ducts and retaining walls are variously of wood and netting, netting on iron or perforated iron. In this type of driers the possible sources of danger are the use of steam-pipes and of fans or blowers. The steam-pipes may cause trouble by actual contact with temporary woodwork or by charring dust or refuse of a combustible sort that may accumulate upon them. Blowers or fans have the usual engine (or electric motor) hazards accompanying them, as well as a bearings hazard of their own. They also produce a draft toward the steam-coils, stir up grain dust and provide drafts which would facilitate the spread of fire. In addition, forced drafts of hot air have a peculiar charring effect upon wood, causing it to ignite at an alarmingly low temperature.

The Hess and Eureka driers column the grain, through which the air is blown, passing first through grain already dried on its way to the steam-coils. These driers possess many advantages and are as safe as can be expected.

Hair Batteries.—Arrangements for drying hair in tanneries or packing plants. Generally screens, gratings or perforated iron floors over steam-pipes or hot-air chambers or both. Enclosures generally frame,

Hanging Rooms.—In tanneries leather is suspended from hooks over steam-pipes on racks along the floor or in rooms warmed by hot air; hazard generally mild. Large frame halls are used in wall-paper hanging rooms, the folds of paper moving in festoons over steam-pipes on racks underneath; a bad hazard in case fire starts owing to construction and desiccated condition of rooms and presence of so much inflammable material. Similar dry-rooms are found in playing-card and coated-paper works.

Hat and Hat Body Dry-Rooms.—In felt, wool and straw-hat factories. Generally frame steam-heated rooms with racks and pegs for the hats or bodies. Steam-pipe hazard only, no gas being evolved from the hats. If stoves supply the heat, the hazard is obviously increased.

Hominy Kilns.—See description of rotary grain driers. The type is used in the various "health food" factories.

Hop Kilns.—The hops are spread to a depth of 18 inches on a slatted floor covered with burlap, and hot air passes up through them from a furnace in the first story of the kiln house. Twelve hours is the usual length of time allowed for drying, one run a day being the custom. Sometimes two runs of 9 or 10 hours are made. In the latter case the fires have to be forced, as greater heat is needed. From time to time the hops are turned over so as to permit even drying.

Various styles of furnaces are used, the most common being box-shaped and horizontal, or drum-shaped and vertical, the flue being coiled about the room before it enters the chimney. The furnace is placed in the center of the room under the slatted floor, in which room sulphur is also burned in a flat dish or pot placed on the furnace, the fumes rising and bleaching the hops. Saltpetre is also similarly burned, in some cases, to toughen the hops so that they will not damage readily in handling.

Chimneys for the furnace are variously constructed of brick, vitrified, unglazed and cement drain-pipes, and iron. They are variously built and supported, the brick ones generally being single.

Kiln house is two stories and the warehouse, always adjoining, also two stories. Generally frame on brick or stone foundations.

Japan Ovens.—For baking enamel or japan on bicycle frames, iron-work of buggy tops, sewing machines, typewriters, etc. They are generally and preferably brick, tile or iron or combinations of these. Sometimes they are frame. If the oven is on a wooden floor its own floor should be two thicknesses of brick laid with cement mortar or one layer on ¼-inch of asbestos on sheet-iron. Doors to be of iron and tight-fitting. Explosion vent to be provided, preferably in the ceiling and leading to the outside air. Heating by steam-pipes on iron supports, preferably at the sides. No open lights should be used near, as the vapors given off during baking are explosive when mixed with air. If other than steam heat, such as that from open gas flames, stoves or furnaces, be used, there should be no direct connection between the interior of the oven and the chamber containing the open flames, otherwise explosions will be imminent. Preferably, japan ovens should be located outside.

Ladle Driers.—For drying out and semi-baking the clay lining in bull and pouring ladles in foundries. Sometimes wood fires are built inside of them; sometimes ovens, somewhat similar to core ovens, are built for the purpose.

Laundry Dry-Rooms.—Generally frame, with sectional sliding-racks to carry the articles to be dried, and heated by steam-pipes. They should be entirely iron or fireproof. Lining with sheet-iron or asbestos does not make them safe. Screens should be provided above the steam-pipes to catch socks, collars, etc., accidentally falling. See also remarks on lumber kilns, many of which apply here.

Lithographed Card Dry-Rooms.—For drying freshly lithographed cards. Generally frame compartments provided with gentle steam heat. Similar to japan ovens, but a milder hazard.

Lithographed Tin Dry-Rooms.—Used also for baking painted and varnished cans. Practically the same as japan ovens (q. v.).

Lumber Kilns.—In general, kilns may be classified as direct-heated and steam-heated. Direct-heated kilns may be further subdivided into what are known as furnace, smoke and open-fire kilns.

Furnace kilns are those in which stoves or furnace-like fireplaces are utilized to supply the heat, the furnace or stove jutting into the kiln-room or being built in a pit inside the kiln structure. In this type metal smoke flues may or may not be utilized to supply a portion of the heat in which they are zig-zagged back and forth or coiled in the kiln-house before venting to the outside air. Obviously, this type of kiln is very hazardous, owing to the possibility of live sparks or heated jets of air escaping from cracks or crevices in the top plate or sides of the furnace or stove or in the smoke flues from them, not to mention the direct exposure of the stock to be dried or portions of the structure by the stoves, furnaces or flues, through accident or poor arrangement.

The open-fire and smoke processes are crude methods in which the stock to be dried is piled or stacked around and over an open fire built in a pit in the ground, the stack being enclosed by common boards laid against it and standing on end or built as a sort of fence. The dangers of this method of drying are obvious, the flames, sparks and smoke passing freely through the piled lumber and providing ripe conditions for the destruction of the edifice, if so flimsy an affair may be dignified with the term. This type of drier has fallen into disuse largely, being found at present mainly in Southern States.

Steam-heated kilns may be subdivided into what is known as natural draft and blower systems. Natural draft kilns are the familiar ones encountered in all parts of the country, wherein live or exhaust steam-pipes are supported from above, arranged in coils about the sides of the room, sometimes placed vertically in the center, or, most frequently, built as a gridiron under the stock. Practically, the only hazard of this type is what is known as the steam-pipe hazard, although what appears yet to be merely a theory has been advanced, that the banking up of hot air and the subsequent admission of cold air into such kilns could produce a fire. The steam-pipe hazard, however, is quite apt to be in its element in such kilns, especially where they are frame, inasmuch as the interior becomes in time desiccated and splinters, short lengths of wood, dust and pitch from the dried stock may accumulate upon the pipes.

In the blower type of kilns, the steam-pipes supplying the heat are located generally in large iron boxes, open at one end for the admission of air, which is drawn from the coils and blown on to the kiln-room by means of fans. The blower and coils used are the familiar hot-air heating apparatus, found so often in use in connection with the heating of churches, halls, schools and factory buildings, the hot air in such cases being delivered to the desired points through metal flues. In addition to the steam-pipe hazard, the blowers or fans in this system of drying have the usual engine or electric motor hazard accompanying them, as well as bearings hazards of their own. The forced draft itself is not negligible as a hazard when a fire has once started, and, in addition, hot-air drafts have a peculiar charring effect upon wood, causing it to ignite at an alarmingly low temperature. It is even stated that warm-air drafts, especially in the form of jets such as might issue from the crevices in poor joints, will ignite wood at ordinary atmospheric temperatures. The explanation of this phenomenon is not at hand, notwithstanding the fact that it seems to have occurred frequently. It is just as well, however, to bear the possibility of fires occurring from this source in mind in the arrangement of kilns. The steam-coils and blowers for kilns are sometimes located in the engine or boiler-house, but are most frequently found in a small addition to the main kiln structure. In many instances the fan-room is crowded, dirty and oily, so that fires starting at the bearings have a good chance to spread and are immediately conveyed to the interior of the kiln. Not frequently it happens that the iron box enclosing the steam-coils rests upon wooden supports. The practice should be discouraged, since the iron enclosure is at practically the same temperature as the coils themselves, and might cause trouble in time. To minimize the danger from the forced drafts in case of fire, it is possible to arrange flap-check valves in the main conduit to the kiln, so that one will fall into place across the conduit, shutting off the draft from the kiln, while at the same time another opens at a point outside the kiln to relieve the bank-up pressure ensuing. One objection to the blower system, which can be overcome effectually only by care as to the arrangement of the apparatus, is the fact that an induced draft is set up and may draw in upon the coils not only foreign inflammable materials, but transient sparks from locomotives, boiler stacks, boiler furnaces or exposure fires while the fan is in operation.

While it would seem that the blower system is much safer than any other in connection with the drying of lumber, it appears that such is not the case, and that natural draft kilns have greater immunity from fires than any other kind. The longevity of any kind of frame kiln, however, seems to be limited to five or six years, on the average, and this fact should not be lost sight of in considering dry-kilns as internal or external exposures.

There seems to be no valid reason why dry-kilns should not be made entirely incombustible, except, of course, as far as their contents are concerned, so that wisdom would dictate that any lumber dry-kiln, whether of the natural-draft or blower system, when inside or exposing a main building, should be absolutely fireproof as regards the material of its own construction. Automatic sprinklers in kilns are desirable, but owing to the manner in which lumber is piled in kilns these cannot operate to the best advantage. Steam-jets, however, in view of the confined nature of the space to be protected, should be valuable in the extinguishment of kiln fires.

Malt Kilns.—For curing sprouted barley in making malt. Of two general types: in one, the heat is from a coke or hard coal fire in a central furnace without a stack, the heat and gases rising through the grain as it lies upon perforated iron floors; in the other, the fires are located on either side of the kiln-room, the heat passing up flues in the walls and entering the space between a slanting iron ceiling and the perforated floor, there generally, in all types, being more than one of the latter. The fires of central-fire kilns are hooded, the sprouts abraded sliding into bins beside the furnaces from which they are removed and sold as feed. Hopper kilns have either wooden, brick or iron-lined hoppers under the first perforated floor, or else the entire hopper is brick, the arches forming it being back to back, as it were, instead of groined. The roof of the whole kiln-house is generally sheathed on the under side on account of the humid, chemical-laden air rising. Fans in towers provide forced drafts, and the bearings of these add a hazard. Preferably, malt kilns should be cut off, as there is some danger of the sprouts igniting, but as they are generally fireproof, the hazard is slight. Steam-pipes are sometimes installed in addition to the furnaces.

Oat-Meal Kilns.—See "Grain-driers." Generally of the pan type.

Oilcloth Driers.—Similar to Butterworth driers (q. v.) in arrangement, but more hazardous owing to the inflammable nature of the stock to be dried. Explosive vapors are also given off, and no open lights should be near. Also danger from static electricity generated by the moving oilcloth.

Paper Calendering.—The drying end of paper engines consists of numerous can driers. Ordinary steam-pipe hazard. Pipes sometimes in contact with floor, but this is nearly always wet. No instances known where engine was clogged long enough for the paper to ignite from the cans.

Patent Leather Enamel Ovens.—First for drying the preliminary coat applied to the leather, consisting of boiled oil, lampblack, umber, etc., and then for baking the coat of varnish which is finally applied after the first coat has been pumiced. These ovens or dry-rooms are of large area and frame, with numerous small detachable doors or covers provided on the front, so that a few of the stretching frames may be entered or removed at a time without disturbing the others or admitting too much cold air. Steam-pipes along the bottom supply the heat, which varies from 120 to 150 degrees. A tarry or pitch-like accumulation forms on the inside, being a condensation of the vapors which emanate during the baking. As in japan ovens, no open lights should be allowed near.

Pepsin Driers.—Small dry-rooms, generally frame, and containing wooden racks to carry the trays holding the cloth aprons or glass plates upon which the pepsin is spread. All odor of gasolene used in dissolving the pepsin has dissipated before the pepsin reaches the dry-room, which involves only the ordinary hazards of frame steam-heated rooms.

Pottery Dry-Rooms.—These are the "green" room, the biscuit-ware room, the sagger dry-rooms and the mould dry-rooms. The green dry-room is for setting or drying the freshly turned or moulded ware preparatory to firing; the biscuit-room is for drying the silicious coating which when burned in the gloss kiln provides the glaze, and the mould-rooms for drying newly-made plaster of paris moulds. All of these are large rooms containing frame steam-heated compartments, with wooden shelves and racks for the ware. The hazard is slight, as the clay dust forms a sort of protection. Sagger driers are frequently similar to brick pan-driers (q. v.), on a small scale, and are for giving a preliminary drying to the saggers before they are burned, saggers being the containing vessels for the pottery to be fired and protecting the latter. They are made of "grog" (broken pottery) and some new clay.

Pottery Kilns.—These are of three general kinds—biscuit, gloss or glost, and china kilns.

Biscuit kilns are tapering or conical-shaped furnaces, substantially built of brick and bound with iron, used for drying or baking the ware from the green rooms. In modern potteries an effort is made to cut the kiln-house or shed off from the main plant, and this is advisable, although the absence of such cut-offs should not be prohibitive. The ordinary furnace hazard is, largely, the danger in connection with biscuit kilns. While actual contact of woodwork with the kiln is usually avoided, the kilns are so thick that this hazard is not serious. It may become so, however, if cracks or fissures should form in the walls of the kiln. A small danger is the proximity of peep-holes, blocked with loose bricks ordinarily, to desiccated beams, which should be tinned near the peep-hole, as workmen sometimes neglect to replace the brick, and the sudden rush of heat from them, also, may start the wood smouldering without being discovered. A more serious danger arises from the opening of the charging door before the kiln has become cool after a "run." This is done in some sections, notwithstanding the fact that it is claimed to be detrimental to the quality of the ware and apt to crack a large portion of it. The dried woodwork above is sometimes instantly fired, as well as subject to ignition from smouldering. Coal or coke fires are generally used.

Gloss kilns are similar to biscuit kilns, and practically the same remarks apply to them. After the biscuit ware is "dipped," the glaze or gloss is burned on. In some ware decoration precedes the glossing, but this precedence is of little significance from an insurance standpoint.

China kilns are smaller, usually, for the finer and more delicate decorated ware. They are generally fire-brick furnaces bound with iron, and involve the ordinary furnace hazards. Used also for burning "stilts."

Sand-Driers.—Where clean sharp sand is needed, as in street-car work for use on the tracks, it must be dried. Driers of various patterns are used. The most common form, and an entirely acceptable one, consists of a large stove, surrounded by an iron drum or hopper, into which the damp sand is shoveled at the top, and from which it trickles at the bottom as it dries. This drier should be set on a cement or brick platform well away from woodwork, and its flues pass to a good brick chimney. Inasmuch as the dry sand issuing is hot enough to be dangerous, not only the floor underneath the drier but the dried sand-bin should be entirely incombustible.

Some driers consist of a gridiron of steam-pipes close together, or of a perforated pan over steam-pipes, with a space underneath for the dried sand. This type is also acceptable if the enclosing walls of the drier are fireproof, but wooden partitions too frequently form these walls and are dangerous.

One form of drier is a tunnel or low furnace, with an iron plate top upon which the sand is piled, one end of the tunnel leading to a flue and the other containing the grate for a coal or coke fire, unless gas flames are used, in which case no grate or chimney obtains. This form is crude and uneconomical, since the whole mass of sand must be heated sufficiently to expel the moisture before any sand is removed. There is no particular objection to it otherwise, except that the walls of the furnace may become cracked, but precautions as to surroundings make this objection minor.

Shellac-Driers (or lacquer-driers).—Generally small wooden or iron ovens for drying shellacked or lacquered ware or parts. Similar to japan ovens of the same type (q. v.). Sometimes mere boxes containing steam-pipes or gas-jets. Latter type dangerous, as inflammable vapors are given off. Larger driers of this sort are used in lantern works and correspond to can dry-rooms in stamping works.

Shoddy Rubber-Driers.—Old rubber, after it has been washed and ground, is dried in screen-bottomed trays over steam-pipes, generally in frame rooms. Hot air sometimes used. A hazard of rubber boot and shoe factories or other rubber factories using mixed stock.

Slashers.—Machines for sizing and drying the warp in carpet factories, ordinary can-driers being used.

Smoke-Houses.—Sausage smoke-houses nowadays are built near the sausage department, and are entirely of iron or brick or combinations of these. Ordinarily, they are two stories in height and appear in practice on the walls outside the sausage department, resting upon iron brackets. Frequently, they occupy a part of the ham smoke-house sections, which may be partitioned off for the purpose. In some cases an entire ham or bacon smoke-house is used for smoking sausages, but large plants nearly always have sections especially constructed for each purpose. The two stories referred to are used as a fire-room below and a hanging-room above, the smoke being furnished by slow log fires in the lower room. The sausages are suspended upon hooks on iron frames on trolleys or mounted as trucks. An iron grating on iron supports furnishes the floor of the upper story, and proper ventilators, extending above the roof of the house, take off surplus smoke. Iron fire-doors cover the openings to each section, the sills of these being preferably a few inches above the floor upon which the wood fires are built. As an additional safeguard, the floor of the sausage department in front of the entrance to the sections is concrete or brick, and ample clearance is provided above the fire-doors to any woodwork. Wooden gratings inside and wooden hanging-rails are undesirable as being ignitible and furnishing fuel in an interior already lined with a tarry soot, although they are not prohibitive if the smoke-houses are properly constructed in other respects.

Ham and bacon smoke-houses are generally built from the ground and are equivalent to from one to six stories in height, with parapeted brick walls, earth or cement floors, and generally timber roofs. The division walls between the section should be blank and all useless openings avoided. Necessary openings should have good iron doors covering the apertures adequately. Although most smoke-houses have wooden roofs, there does not appear to be any real necessity for this construction, and modern packers are building the roofs entirely of iron or brick and iron. Heretofore, also, the gratings and rails from which to hang the stock have been wooden, but these are being discarded for iron gratings and steel rails. Instead, also, of hanging each ham or strip of bacon upon a rail or hook on the 4x4s formerly used, iron arbors or frames carrying a number of pieces are now mounted on trucks or suspended from a trolley and run into the smoke-houses. In the latter instance the fire-doors should be built so as to be tight-fitting at the rails, or else the rail openings should be provided with automatic flaps or slides. An excellent device for this purpose consists of a slide pushed into place, as the door is closed by a rod attached to the door near the hinge side. A great deal of leverage is obtained in this way, insuring reliability of action.

The sills on the lowest doors of smoke-houses should be a foot or more above the firing-floor in the bottom to prevent an overflow of grease in case the contents burn out. It is well, but not essential, to have an iron hood over the wood fires to prevent grease from dripping on the fires and causing them to flare up. The lowest grating, however, is nowadays placed high above the fires, so that accidents from this source are rare. Oak logs are generally used to feed the fires, although other woods are used occasionally, and when wood is scarce, corn-cobs are sometimes utilized.

Under ordinary circumstances smoke-houses are not dangerous, and fires in them burn out harmlessly, but the very high ones when full of stock and on fire may damage the ham-house adjoining, as a result of the meat falling in bulk, causing the fire-doors to bulge out and thus allow the fire to communicate with any woodwork near. Where strings and wooden hanging-rails and no gratings obtain, the danger from this source is greatest. It is not at all a supposititious danger, as an accident resulting in considerable loss has actually occurred from meat falling and bulging out the fire-doors. Iron floor gratings at the ham-house floor levels, by limiting the amount of meat which could accumulate at one point, reduce this hazard very materially. Where such gratings are provided and iron arbors and hanging-rails as well, it is practically eliminated.

In examining smoke-houses, care should be taken to see that the floor beams or headers do not lie too close to the tops of the doors, as they may be ignited by a fire inside. Preferably, there should be a clearance of several feet over the tops of the doors to any floor joists or woodwork. The best construction, and one which may be regarded as standard at the present time, is that in which the smoke-houses themselves are brick and iron, as already described, and set in or adjoining a filling or handling section of fireproof construction, cut off from the ham-house by fire-doors. The filling hallways are now generally joisted and are frequently not cut off from the ham-house. While the standard construction advised is rather more expensive, the security and convenience of arrangement will more than offset the difference in cost.

Snuff-Driers.—In snuff factories, for drying the tobacco from which the snuff is made. They should be of brick, and the conveyors on which the tobacco passes through the kiln should be entirely of metal. No inflammable material should be used in the construction of the kiln, which should also be cut off from the factory. Preferable methods of heating are steam-coils and hot air. Dust accumulations within the kiln should be carefully guarded against, as, at the temperature used, explosions are imminent.

Soap Dry-Rooms.—Bar and cake soap in the factory are dried atmospherically, as a rule, with the assistance of a fan. Sometimes steam-coils are placed in the rooms or the air is drawn through coils before it passes to the dry-rooms, which are long, low, frame, tunnel-like compartments. Chipped soap is dried on trays on racks over steam-pipes, or in rooms heated by hot air circulated by a fan.

Sole-Driers.—In shoe factories. Generally shallow wooden or metal boxes or trays, with steam-pipes or gas-jets under the sheet-metal or wire screen bottom.

Starch or Crusting-Kilns.—Block starch, in starch works is baked or dried in frame compartments, heated by steam-pipes under the wooden racks supporting the trays carrying the starch. Sturtevant or similar apparatus is also used. These rooms are numerous and sometimes extend through several stories, and, as they are also dried out, form a bad feature. More modern factories are using fire-proof oven-like kilns.

Stock-Driers.—In cotton and woolen mills, for washed stock. Of various types. A familiar form consists of a bin, generally of wood, with a gauze wire bottom. The stock is piled on the wire bottom and heat from steam-coils in the hollow space underneath is forced up through the stock by a fan. Sometimes the heat is from coils beyond the fan, and often from combinations of the two systems. Occasionally, frame or fireproof buildings, with one or more grated floors, are built for the purpose, the same sources of heat being used. Care should be taken to keep the pipes free from wood and stock accumulations.

Tenter Frames.—In dye works and bleacheries. Cloth is engaged at its edges by tenter hooks which then spread apart on a frame to stretch the cloth. In some cases the cloth remains stationary on a long frame, and a car containing a charcoal fire is passed under it.

In others the cloth passes over and between steam-coils until it is dried. First method antiquated and dangerous.

Tobacco Drying.—This is done in dry-rooms and rotary driers. The dry-rooms are for leaf tobacco and generally wooden, possibly metal-lined. Steam-pipes or hot air are used for heating. Particular care should be taken to keep pipes free and bearings of fan clean. The rotary driers are for fine-cut tobacco and are similar to feed-driers (q. v.). If direct-heated they are very hazardous, and should be in roomy, fireproof surroundings.

Tube Driers.—In knitting mills, for drying the long, continuous knitted pieces, afterward cut up for undershirt bodies. One end of the tube-like cloth is placed over the mouth of a metal flue or tube through which hot air from steam-coils is blown, the goods ballooning out and drying. Coil and fan hazard. Trouble might be caused by burning particles from coils or fan being blown into cloth when dry.

Varnish Dry-Rooms.—For facilitating the setting of varnish applied to articles, and are generally frame rooms heated by steam. Except that an inflammable vapor may accumulate and explode upon the entrance of open lights, the hazard is that of steam-pipes and dry interiors. Stoves, if used, are dangerous, and should be discouraged, except under the most careful regulations. A gentle heat is used ordinarily. These rooms occur in coffin works and light wagon body and carriage factories; sometimes in other risks of a similar nature.

White Lead Dry Pans.—In white lead factories the stock is settled in shallow iron pans and dried, sometimes over steam-pipes and again by steam in the hollow bottoms. Ordinary steam-pipe hazard, unless the pans, as occurs occasionally, are enclosed in wooden partitions which add the hazard of desiccated wood.

Wool-Driers.—In woolen mills, as mentioned, and in wool pulleries. See "Stock-Driers."

Yeast-Driers.—The moulded cakes are dried in small frame, steam-heated rooms, being set in pans on racks.

Kettles

The principal features in connection with these are the manner of heating, the nature of their contents and chances of it causing trouble, and the fact that the kettle is closed and used under pressure or open. To save repetition and description in each case, it may be well to call attention to the fact that direct flames, especially other than gas, are not so easily regulated and result in boiling over or excessive ebullition of a sputtering sort, so that, even if boiling over does not ensue, the surroundings may be spattered.

Brewing Kettles.—Generally copper and enclosed, but not used under pressure. Formerly set on brick furnaces with coke or coal fires, but nearly always nowadays heated by steam.

Cookers.—Used in distilleries, breweries, linseed-oil mills, cottonseed-oil mills, cereal food plants, etc. In distilleries they are cylindrical iron tanks, on iron legs, with wooden platforms on top of them for cooking the mash. Subject to rapid variations of temperature, as the mash is cooled rapidly after being cooked. Some danger of explosion on this account. In breweries, for practically the same purpose and similar apparatus. In linseed and cotton-seed oil mills they are for cooking the ground seed or meal to start the exudation of the oil, and are a worse hazard. They are iron, steam-heated receptacles containing stirring paddles; no wooden enclosure should be allowed about them, as these become oily and act as catch-alls for stray meal, etc., causing numerous fires. Cookers for grain, etc., involve steam-pipe hazard only.

Digesters.—In paper and strawboard mills, for digesting wood, rags or straw. Cylindrical or spherical rotating iron vessels in which the raw stock and chemicals are mixed with steam under pressure. Steam-pipe and explosion hazard.

Doublers.—Redistilling apparatus. See " Stills."

Dye Tubs.—In dye works. Wooden or copper vats almost invariably heated by steam nowadays. Surroundings wet and hazard negligible.

Fried Cake or Cruller Kettles.—In bakeries and sometimes in dwellings. Shallow kettles or pans containing melted lard, into which the dough is dropped and fried. Generally heated by direct fire and a bad hazard. Surroundings generally greasy, as the boiling and bubbling lard sputters over neighboring walls, partitions and floor. Should be in fireproof surroundings if used regularly.

Glue and Paste-Pots.—These would appear to be comparatively innocent as hazards. They are prolific sources of fire, however, especially as frequently heated and arranged. About the most hazardous heating device is an oil stove. Frequently small stoves, which are little more than lamps with tin chimneys surmounted by rests for the pots, are used, being carried from place to place and allowed to rest on benches, boxes, shelves, etc. They are top-heavy, unstable and easily upset. Next in hazardousness is the small regulation iron base oil stove. It is not so easily upset, although far from immune from such accidents. In both types over-heating of the oil in the base, explosions and boiling over of the glue on to the flames, are ever-present dangers, in addition to the direct exposure of inflammable materials, such as patterns, shavings, shelving, benches, etc. Both kinds should be prohibited unless well enclosed in metal boxes having only one side open and set in trays with sand under the stove.

Gas-jets are less objectionable, but carry with them the objection to open lights, use of matches, direct exposure to inflammable materials, etc. Very often otherwise arranged glue-pots are found in a recess below a bench so disposed as to endanger the under side or supports of the bench. Particular pains should be taken in examining such devices to see that the flames or heat from them does not lap around the bottom or sides of the pot in such a way as to expose woodwork or heat up the enclosing metal case, so that it will expose woodwork. Gasolene torches are sometimes used and should be absolutely prohibited.

Steam-heated pots are the safest, all things considered, the only danger being that in the steam-pipes leading to the bath or heater, as a rule. Ordinary warming-coils, caul-boxes and dry-boxes are often utilized for heating the pots, but without increase of hazard. An excellent type of heater is a small hollow iron disc, heated by steam, and resting on iron supports. The surroundings of such heaters are easily kept clean, whereas the battery type of jacketed heater has a tendency to become dirty.

Hot Water Kettles.—In various risks, such as breweries, dye works, plating works, etc. Method of heating most important feature.

Licorice Kettles.—In tobacco factories. Steam-jacketed iron or copper; sometimes stove-heated. Used for melting and preparing licorice in flavoring tobacco. Rum and alcohol are sometimes added in flavoring, being especially significant if the kettle be direct-heated.

Lye Kettles.—In soap factories and chemical works. Generally iron and steam-heated, containing strong lye water.

Mash-Tubs.—Steam-heated iron vats for preparing mash. Generally contain stirring paddles.

Mixing Kettles.—No particular type. For various purposes, in chewing gum mixing, varnish mixing, pharmaceutical works, making stuffing grease, etc.

Oil-boiling Kettles.—In linseed-oil, varnish, patent-leather and cheap paint-mixing works principally. Generally iron or copper kettles set on low brick furnaces, and using coal, coke, wood, gas, etc., as fuel. Great danger of boiling over and should be in fireproof surroundings. They are generally built on hearths, with hoods and flues above.

Oil-warming Pots.—In tanneries oil at tables is warmed in shallow kettles or pots generally by steam, but sometimes by oil lamps, jets, etc., in which case they are dangerous.

Pharmaceutical Kettles.—This heading includes the various copper or iron, steam or direct-heated kettles used in pharmaceutical works for making elixirs, extracts, infusions, decoctions, syrups, porous plasters, etc. They are mostly for melting or boiling. Steam-heated ones a mild hazard; those direct-heated may be serious, depending upon substance heated and environment.

Pitch-Pots and Kettles.—In breweries, for melting pitch to line kegs with. See "Tar and Asphalt Kettles" and "Pitching Apparatus."

Process Kettles.—In canning factories. Really cooking kettles. Sometimes enclosed entirely with covers. Steam-heated nowadays and a mild hazard.

Rendering Tanks.—These are large, vertical iron tanks, 4 to 6 feet in diameter, generally steam-heated and extending from the first to the top story of the rendering house. They are made of riveted boiler iron and are provided with trapped openings for the admission of offal. When they are steam-heated the danger from them is small, being an ordinary steam-pipe hazard; and the clearance of the tanks and pipes to them is practically all that needs to be considered, as gasolene is not used in rendering tanks in packing houses. If heated by direct fires, however, which is seldom done in any but small plants, they may become very hazardous. Their manner of heating is then important, as well as the usual features of clearance. The charging floor is always more or less oily and greasy, although many well-regulated plants reduce this objection to a minimum by care.

Rosin Kettles.—For melting rosin in varnish works, in pipe bending, etc. Apt to boil over; if direct-heated, a bad hazard, and should be set in fireproof surroundings if inside.

Salt-Pans.—Huge iron kettles for evaporating saline water. Steam or direct-heated. Generally in light frame structures, which become thoroughly desiccated and the floors of which are apt to be in contact with the sides of the pan or kettle.

Soap Vats or Boilers.—Huge iron or wooden, generally the former, vats or tanks used in the final boiling operation of soap-making. Generally steam-heated and a mild hazard. Sometimes direct-heated, the furnace hazard then being important. Surroundings generally slopped with soap stock, giving an appearance of hazardousness which does not exist.

Steamers.—In a variety of risks for varying purposes, but generally involving the same principle. For steaming logs in turned veneer works, articles to be bent in wood-workers, bottled beer in breweries, etc. Generally a tight chamber to which steam is admitted. Steam-pipe hazard only.

Stills.—In various classes of risks, for driving off volatile and condensable matter, such as alcohol, gin, rum, naphtha, water, pyroligneous acid, etc. Generally a closed vessel, with an outlet conduit at the top to a worm or condenser of some sort, the vapors passing over and being cooled to liquefy them. In all stills where inflammable vapors are given off, direct heat is dangerous in addition to the usual furnace hazards, as leaks and explosions may occur.

Stuffing Grease Kettles.—For mixing and preparing stuffing grease (neatsfoot-oil and tallow, largely) in tanneries. Generally open iron, steam-heated kettles, the surroundings being greasy, as a rule. If direct heat be used, they are a bad hazard inside. Table grease, or excess grease scraped from the leather in setting, is reclaimed, as well as that from greasy scraps, in similar or the same kettles.

Sugar Kettles.—Specifically, those used for boiling sugar and glucose in candy factories. Generally steam-heated and copper. Direct-heated kettles for the purpose are called candy furnaces (q. v.).

Syrup Kettles.—Practically the same as the above. Used mainly in making syrup from sugar, in making extracts, elixirs, etc., and in reducing syrups to sugar.

Tar and Asphalt Kettles.—Both portable and stationary. Used in roofing houses, paving streets, caulking decks and heavy floors, making electrical insulation, etc. Generally direct-heated and apt to boil over. Should be used only in fireproof surroundings.

Varnish Kettles.—Specifically, the last mixing and boiling kettle in varnish making. Direct-heated, being, as a rule, mounted on trucks so that they may be quickly withdrawn from over the fireplace, the operation being critical as to ultimate quality. Used, as a rule, in huge brick hearths in fireproof surroundings. Prohibitive inside main buildings.

Vacuum Pans.—A type of evaporating or boiling apparatus, utilizing the principle that substances in a vacuum boil at a lower temperature than ordinarily. Closed copper or iron kettles, air being exhausted after the stock is admitted. Pans of the sort may be single, double or multiple effects. Principal uses are in making beef extract, malt extracts, "stic," glue, sugar, glucose, beet sugar, condensed milk, bark extract, etc. Steam-heated and a mild hazard.

Wax-Pots.—For melting sealing-wax used in setting bicycle tires, beeswax and cobblers' wax in shoe factories, stearine and paraffine in candle making, and packing sausage for export, pattern makers' wax, etc. In shoe factories wax-pots are now on the machines and steam-heated or warmed by small gas-jets, but formerly they were variously heated and detached. If direct heat be used in any case, fireproof surroundings are necessary to prevent loss in case of upsets, boiling over, etc.

Miscellaneous

Acids.—The principal hazardous acids of commerce, with their predominant characteristics, are as follows:

PICRIC.—Commercially in yellow prisms or crystals. Fuses at 246 degrees F. Explodes at 600 degrees and highly dangerous when steam or water is dashed on it. Soluble in water, alcohol and gasolene. Used as a hop substitute in making beer and in dyeing silk and wool; also in making explosives and in solution in gasolene for use in gasolene engines, gasolene absorbing five per cent of it. Explodes easily when mixed with red lead or other oxides, such as iron rust. Sodium salt of picric acid, sometimes sold as picric acid, is very explosive and dangerous. Ammonium and potassium picrate are also very explosive when heated or struck.

SULPHURIC, OR OIL OF VITRIOL.—Colorless when pure, but light brown or yellow in its cheap commercial forms. Heavy and oily. Kept ordinarily in carboys. Most widely used of all acids in arts and manufactures. Absorbs water so rapidly, with the evolution of heat, that the sudden addition of water will cause an explosion. Chars many substances by deoxidizing them, this property rendering it dangerous. Poured on sugar, it inflames. It attacks all ordinary metals but lead, corrodes all cloths and most combustibles, and reacts upon a great many chemicals. It should, therefore, be handled and stored with care to prevent spilling or breakage of the carboys.

NITRIC, OR AQUA FORTIS.—A colorless, corrosive liquid, kept ordinarily in carboys. Used widely in the arts and manufactures. Attacks all metals except gold, platinum and aluminum. Sets fire readily to dry packing materials, such as straw, sawdust, paper, etc., and nitrates produced by its action are also likely to oxidize and set fire to combustibles mixed with them. It also sets fire to wood in bulk if allowed to soak into it. In contact with phosphorus, charcoal and many other substances in common use, it inflames. Steel, iron or brass filings on floors, mixed with it, cause it to give off deadly fumes which, together with the evaporating acid, render it extremely dangerous for firemen or workmen. It should be handled and stored with great care.

ACETIC.—Practically the same as vinegar. Boils at about 240 degrees F., giving off a vapor which burns like that of alcohol, otherwise practically non-hazardous as ordinarily found and used.

HYDROFLUORIC.—Colorless liquid, fuming strongly in the air, with a pungent irritating odor. Boils at sixty-seven degrees F. Corrodes glass rapidly and kept ordinarily in gutta percha bottles. Combines with sulphuric and phosphoric anhydrides with great evolution of heat; likewise with water.

HYDROCHLORIC OR MURIATIC.—This has a suffocating odor and very strong attraction for water, otherwise it is comparatively harmless. Commonly, it has a bright yellow color, and is stored in carboys.

Bale Openers.—Cotton bales should not be opened with an axe, as it may strike fire on the bale-ties and ignite the cotton. The spark may smoulder for hours and break out after the stock has been carried to the mill. A duck-bill wrench should be used, this to have one edge beveled to prevent a broken bit of the bale-tie from remaining in the bale.

Banana Ripening.—In connection with wholesale fruit-houses green bananas are ripened by artificial heat, generally from open gas-jets or crowns along the floor. Inasmuch as considerable packing-straw is about, as a rule, this is a dangerous practice, and care should be taken to see that the burners are properly shielded.

Bark Mills.—Generally in connection with tanneries. For grinding the bark used in the leach-tubs in preparing the tanning liquor. Of two general kinds, one being like a vertical corn-sheller and the other a chipper, in which radial blades on the side of a wheel cut up the bark. Both kinds have dusty surroundings and explosions can occur. Shafting hazard also considerable, and if belt-and-bucket elevators are used to convey away the bark these should have self-cleaning heads. Wooden conveyors generally remove the bark. Bark mill-house should be cut off.

Batch Warmers.—For warming candy batches in making stick and other candy shaped by hand. They are variously built. Sometimes a steam slab or table, with a coil set vertically on top; again a direct-heated plate, the low wall of jets or low furnace (charcoal) set on top. Arrangement of heating device and clearance at tables important.

Bending.—Bending is done in various ways, some of them involving hazardous processes in the actual bending, and others not. In many instances—in the case of shovel, post-hole digger, wheelbarrow, plow and corn-planter handles, felloes, etc.—the object is steamed and bent and then set in regular dry-rooms while still in the frames holding them to the desired shape. There exists here the steam-pipe hazard in connection with the steaming-vat, as well as the dry-room hazard. In other cases steam-heated frames are used to expel the moisture from the bent stock and set the latter to the desired form. Such apparatus is used where buckling or other warping than that designed is to be especially avoided, and we have only the steam-pipe hazard.

A different type of bender from the above is what is known as a panel-bender, used for curving or warping pieces, generally with the grain running parallel with the cylindrical surface and depending upon heating one side only of the work. Coach door or body panels, guitar sides and pieces of similar description are bent in this way. Curved plates, cylinders, etc., of iron serve as forms upon which to lay the work, being variously heated by gas or gasolene flames, small fires or steam.

Benzine.—Highly volatile and inflammable colorless liquid. Fumes heavier than air and apt to accumulate in partly empty vessels or fall to floor and hang together until they reach an open flame. Such fumes have traveled 100 feet to a flame and flashed back to the vessel. Benzine vapor and air mixed are very explosive. Benzine is used mainly for cleaning, especially greasy or oily surfaces.

Bleaching, Sulphur.—In various risks—hop-kilns, malt-kilns, broom factories, rattan works, etc. Generally by burning sulphur in an iron or stone pot in a tight room. As sulphur boils over readily when burning, the pots should be of ample capacity and preferably on fireproof floor.

Board Scrapings.—In cutting upper leather, principally in shoe factories, the cutting boards are coated with linseed-oil to prevent their surfaces from chipping too easily. These boards have to be planed every week or two to level the surface up, and the process is called "scraping." The refuse is subject to spontaneous combustion and should be removed separately.

Branding.—In breweries, distilleries and other risks using barreled, boxed or kegged goods; in packing houses, on hams and bacons. Irons with imprints, letters or marks are selt-heated or heated in forges, stoves or salamanders. Self-heated irons are stationary or portable, the former being set on tables and heated from the under side. Rests should be provided for portable irons. Clearance and method of heating important.

Breechings.—See "Boilers."

Brush Machines.—Cloth-cleaning machines in textile mills. Dust and shaftings hazard.

Buffing.—Polishing by means of cotton wheels and rouge. Considerable dust and fly or lint raised. Shafting becomes clogged, flashing of refuse is imminent and spontaneous combustion may take place in refuse accumulations on account of the stearine used as a binder in the rouge.

Bunsen Burners.—A type of gas-burner in which air is admitted back of the burner to increase the heat. Used in various apparatus. Specifically, a small tube burner, with a heavy base to keep it from upsetting, used in laboratories, jewelry repair work, tube and vial works, etc. Rubber tubing to them rots or becomes loosened, and may cause trouble.

Candles.—Hazard of these arises from their habit of softening and falling over, of burning down and upsetting. Too frequently stuck on woodwork and left to burn alone.

Carbureters.—See "Gas-stacks and Retorts." Carbureters for enriching gas or making gasolene gas are variously-built chambers, usually made to expose a large surface of gasolene to air passing over it. They should never be inside, but outside and well removed.

Cartridge Filling.—Hazard due to presence of powder loose and chances of detonation or ignition accidentally. Should be done in roomy, fireproof surroundings.

Carpet Sewing.—Where electrical machines are used, the usual small electrical motor hazard is present.

Catch-basins.—The waste products of gas-making are drained to tanks let into the ground, the top being flush with the surface of the ground. Through derangement of the apparatus and other causes, volatile by-products sometimes escape into the catch-basin, and may be ignited by stray sparks falling through open covers, and as the sides of the catch-basin are usually coated with tar, a smart fire results from the woodwork, the tar and the lighter by-products. The catch-basin should, therefore, be so located as not to expose adjacent property.

Celluloid.—Made by treating pure cotton or tissue paper with nitric acid and mixing the product, called pyroxylin, with camphor, coloring matter, alcohol, and sometimes oil. Highly combustible, taking fire without flame at about 300 degrees F. Used as a substitute for ivory, bone and shell. It can be cemented, a cement consisting of a solution of pyroxylin in alcohol and ether being used. The cement is equally dangerous.

Chemicals.—These are too numerous and have too many characteristics to be treated in detail here. The more common, therefore, will be treated briefly:

Acetone.—A colorless liquid with a sweetish odor, and very inflammable.

Acetylene.—A colorless gas with a garlicky smell. Produced commercially by treating calcium carbide with water. Used as an illuminant and to supply heat. The gas in air forms explosive mixtures, the percentage varying from 3 to 82.

Alcohol.—A volatile, colorless liquid, burning in air with a bluish, almost invisible flame. Its vapors form explosive mixtures with air.

Ammonia.—A gas consisting of nitrogen and hydrogen. Dissolved in water, it is known as ammonia water, ammonia liquor, aqua ammonia, etc. It decomposes into its elements at 900 degrees F., but is not combustible at ordinary temperatures. It is not explosive, but when liquid ammonia is stored in drums, with insufficient space left to allow it to expand, the drums may burst on warm days. Saturated with oil, it will explode if lighted.

Calcium Carbide.—A grayish crystalline solid. In contact with water it forms acetylene, and should be kept in tight, fireproof boxes.

Camphor.—Very inflammable, burning with a bright, smoky flame.

Carbon Disulphide.—An extremely inflammable liquid, colorless when pure. It ignites at a very low temperature and may be exploded by shock. One of the most dangerous substances used in the arts.

Chlorate of Potash.—A salt rich in oxygen which is weakly held in combination, making the compound dangerous. When heated, it decomposes, with the evolution of more heat, into potassium chloride and oxygen. If mixed with combustibles, therefore, and ignited, the oxygen liberated causes rapid combustion. If melted and brought in contact with coal gas, it burns spontaneously. It forms dangerous combinations with many other substances, and the kegs in which it is stored should be kept outside.

Coal.—Soft coal is subject to spontaneous combustion under certain conditions not definitely known, and should not be stored in quantity where it exposes woodwork.

Collodion.—A solution of gun cotton in ether and alcohol.

Ether.—An extremely volatile, colorless liquid. Its vapors are heavier than air and very inflammable. The cans containing it should be kept in a cool place.

Fusel-Oil.—A mixture of alcohols, amyl alcohol being its chief constituent. An oily liquid slightly yellow in color and very inflammable.

Hydrocyanic Acid Gas.—A very poisonous gas. Inflammable. Mixed with air in certain proportions, it explodes. Used for killing weevils in mills and elevators.

Hydrogen.—A colorless, tasteless, odorless gas, the lightest of all known substances. It burns in contact with oxygen, and in air forms explosive mixtures, the percentage varying from 5 to 80. Commercially, kept in cylinders.

Lampblack.—A form of carbon consisting mainly of the soot from the smoky flames produced by burning in an insufficient supply of air highly carbonaceous substances. It is subject to spontaneous combustion and should be kept in metal receptacles.

Lead Nitrate.—When mixed with organic matter and rubbed or subjected to friction, it may cause ignition.

Marsh Gas or Methane.—A hydrocarbon produced when vegetable matter decays in the presence of moisture. Sometimes confined in layers of coal. Inflammable and forms explosive mixtures with air.

Oxygen.—A colorless, odorless, tasteless gas, the basis of combustion. It enters into combination readily with numerous substances, the combination evolving heat. Kept commercially in cylinders.

Phosphorus.—Generally in the form of yellow or whitish sticks. It inflames at 111 degrees F., and should be kept under water. The flame of phosphorus, however, does not generally ignite solid substances, although it sets fire readily to paraffine, sulphur or wax, and in contact with chlorate of potash it may cause a violent explosion.

Rosin Spirit.—A colorless or slightly yellow liquid, with a low flash-point, very volatile and inflammable. It absorbs oxygen from the air with the production of heat.

Saltpeter or Nitre.—Many similar characteristics to chlorate of potash, being rich in oxygen weakly held in combination. One volume of nitre represents 3000 of air in its power for supporting combustion. Fires in the bags in which it has been kept burn fiercely, therefore, and can occur spontaneously. In contact with hot coals it deflagrates violently.

Sodium and Barium Peroxide.—Bleaching powders of a highly dangerous nature. Mixed with wood dust and struck, they explode, Either should not be scattered on the floor, as the contact of a heel with it would cause a fire.

Sulphur.—Comparatively harmless alone. It burns freely, but does not ignite at less than 500 degrees F. Its vapor explodes spontaneously when mixed with air. It may be detonated when mixed with chlorate of potash, and is ignited by phosphorus flames.

Compounding and Laboratory Work.—This involves, besides the use of retorts, Bunsen burners, small ovens, etc., the mixing of chemicals which may inflame, detonate or explode. Compounding in wholesale drug stores, as generally found, is a misnomer, being mechanical mixing of substances which do not unite chemically. The closet or hod used to carry off noxious fumes should be fireproof and not frame, as generally happens.

Dipping.—Reference is made to the rapid process of immersing the object in a bath of oil, paint or varnish, and then withdrawing it and allowing the coating to dry. Where benzine, cut paint or varnish is used, the hazard is obviously most serious. Ordinarily, the dipped articles are stacked or hung over a trough draining back to the dipping-tank. The latter should be iron and provided with a cover which may be let down to smother flames in the trough. The hazard of dipping is due to the presence of the inflammable coating, the spattering of this around, the vapor or fumes from it, and the chances of ignition by lights or static electricity, not to mention the presence of newly-dipped stock in quantity.

Dust Hazard.—Briefly, this is due to the rapid ignition of dust particles suspended in air, the ignition being so rapid as to amount to an explosion. The dust of any substances which will burn or oxidize will explode when properly mixed with air. Dust also clogs bearings, causing them to heat, and many dusts settling and becoming oily may ignite spontaneously.

Egg-Candling.—Generally in commission houses, packing houses and other risks handling eggs in quantity. Candling consists in holding the eggs before a light, formerly from candles, to ascertain if they are addled or not. Oil-lamps, gas-jets, incandescent lights and daylight are also used. Jets, candles and oil-lamps are very dangerous, owing to crowded nature of candling compartments and presence of so much inflammable material.

Electrical Hazards.—In brief, electrical hazards are due to heating of conductors or parts, to arcs and to leaks. Heating is caused by overloading which itself may be due to short-circuits, poor joints, poor contacts, lightning, crosses with currents of higher voltage, too many lights or motors on a line or to intention, as in electric heaters. It is also caused by induction, as in choke coils and magnets which are rapidly magnetized and demagnetized. Arcs are the jumping of current across an air space, being caused when a circuit is broken by accident or design. Arcs may be produced by leaks which gradually become severe enough for a sudden rush of current, by switches, by short-circuits, by burn-outs, etc. Leaks are due to the breaking down of the insulation through one cause or another, and may lead to heating or arcs.

There are also in connection with electrical apparatus numerous dangers of a mechanical or physical rather than electrical nature, such as the breaking of lamp globes in inflammable vapors, the fracture and sputtering of arc-light carbons, the ignition of materials, by contact with incandescent lamp bulbs, etc.

Electro-plating.—This is done by first washing the piece to be plated with concentrated lye or benzine and lime water, to remove any grease, and by rewashing with dilute sulphuric acid to neutralize the previous wash. The "work" or part to be plated is then attached to the negative pole, and a nickel, copper, silver or gold slab or plate, as the case may be, to the positive pole of a low potential dynamo, after which both are immersed in a bath of copper sulphate or other electrolyte. The current being turned on removes molecular particles of the slab or metal to be transferred and deposits it on the surface of the "work." Plating dynamos employ a difference of potential of from two to four volts. The bus wires are almost invariably bare and often run on wooden supports, but there is no danger of leakage with the low voltage used. There is, however, some little hazard in connection with these dynamos and wires. Pieces of metal laid or dropped across the bus wires, terminals or brushes would be instantly fused, and if the molten metal fell into inflammable material trouble might ensue. This is really about the only considerable danger in connection with the dynamo and its appurtenances, and it is generally remote. Electro-plating, however, involves the use of materials and incidental processes which are more or less hazardous—i. e., lacquers, lacquer-drying ovens and buffing.

Electro-typing.—A matrix, consisting of graphite and wax, is made by pressing into the surface of the composition type forms or cuts. The type metal is then deposited upon the matrix as in the case of electro-plating (q. v.). Wax-heating pots are an accompanying hazard.

Embossers.—Machines for pressing patterns or wood in imitation of carving, or designs on leather or book covers. Heated to give permanence to the designs which could otherwise lose their sharpness of outline and contour. Method of heating the most important feature. Gas generally used; occasionally live steam. Apt to be used in the midst of inflammable materials.

Engines.—In all types of engines there is present in a greater or less degree the grease hazard. In fly-wheel engines there is the danger of the wheel bursting and causing damage from which fire may ensue. Gas engines may have flame igniters, which should be well away from inflammable materials; the muffler and exhaust should be clear also, and the exhaust should extend to the outside air and never enter flues or stacks unless the latter are large. Gasolene engines should never have flame igniters if they are inside, and the supply should be outside underground and never gravitate to the engine, otherwise the remarks on gas engines apply. The live steam and exhaust pipes of steam engines should be free.

Etching and Pyrography.—In etching by gas flames, such as that done on bamboo, the jets should have proper rests or racks when not in use, and the rubber tubing should be kept in repair. The surroundings should be neat also, in case the jets are dropped accidentally. Somewhat similar remarks are true of gas-heated tools, and the heating devices should be watched. The wires leading to electric gravers should be properly insulated and protected against wear and injury, and adequate rests provided for the instruments when they are not in use. Particular care should be taken with the gasolene bulb apparatus used by artists and amateurs.

Explosives.—Gunpowder, a mixture of saltpetre, sulphur and charcoal, ignitible by flame or by heat varying from 554 degrees for black, to 579 degrees F., for brown, prismatic powder.

Guncotton consists of purified cotton treated with a mixture of 1 part strong nitric and 3 parts sulphuric acid, resembling ordinary cotton in appearance. It can be exploded by percussion, flame and the shock produced by fulminate of mercury.

Nitroglycerine is made by the action of strong sulphuric and nitric acids upon glycerine. It is an oily, colorless liquid and poisonous. It explodes at 356 to 392 degrees F. It is easily exploded by shock and extremely dangerous to handle.

Dynamite is a mixture of nitroglycerine and some absorbent, as silicious earth, magnesia alba, mica powder and charcoal.

Blasting gelatine is made by dissolving guncotton in nine times its weight of nitroglycerine.

There are many other explosives, but the above are those appearing commercially in this country.

Feather Renovators.—Apparatus for dusting, steaming and cleaning feathers. Steam-pipe and dust hazard. The impression obtains that feathers will not burn, but the down near the quill will flash and make a quick, intense fire.

Finishing.—The term finishing generally includes filling, rubbing and the final finishing, and is frequently extended to include varnishing as well. Varnishing, however, has been treated elsewhere, embodying somewhat different hazards. The first operation in finishing is filling, which consists of filling or plugging the pores of the wood so that it will present a smooth surface and not absorb too much varnish. Fillers are made of various combinations of silex, silver white, corn starch, whiting, plaster of Paris, raw and boiled linseed oil, turpentine, japan and benzine. Sundry pigments are used to color fillers, depending upon the character of the final finish desired. The principal among these are raw and burnt umber, raw and burnt Italian sienna, Vandyke brown, drop or ivory black and rose pink. Both turpentine and benzine ground japans are used. Fillers are generally in paste form and are thinned down for application, turpentine, naphtha or refined linseed-oil being used. No more linseed-oil is used than necessary to form a binder, as it prevents the filler from drying or setting rapidly. Excess filler is rubbed off with curled moss, excelsior, shavings, soft sawdust, tow and waste, as the case may be. Flax or hemp tow is used in finer, and the other substances in cheaper grades of work.

Shellacking follows filling for the purpose of sealing the pore depressions. This is sometimes done with ordinary alcohol shellac, but may be accomplished with other substances, the operation, however, being known as shellacking irrespective of the materials used. When this is dried, the varnish coats are applied and the various rubbings follow.

Rubbing is done with either water or rubbing oil, the latter being a petroleum product resembling machine oil and not dangerous. Linseed-oil can be used, but is much more expensive and not so satisfactory, being more gummy than rubbing oil. It is also more hazardous. Pulverized pumice or rotten stone is used to hasten the cutting action of the rubbing process. In the final rubbings of fine finishes water or the hands alone are used. Ordinarily, the rubbing oils and pumice or rotten stone are applied and rubbed in with rags, old silk cloths or handkerchiefs, chamois skins, or rubbing felt. After the rubbing is done, a damp, soft wood sawdust is generally used to clean off with, being sprinkled over the surface and removed with cotton waste or soft cotton wadding.

The hazardous features of filling, rubbing and finishing arise from the use of finely subdivided waste and materials in conjunction with oils which absorb oxygen freely and from the use of volatile liquids. Linseed-oil is especially subject to spontaneous heating, and the hazardous nature of the other oils and liquids has been pointed out under "Painting." Flemish finishes are thinned with amyl-alcohol, the substance so frequently used in cutting lacquers and very volatile. It should be treated in much the same manner as naphtha. It is almost unnecessary to add that standard waste-cans should be provided for the rags and materials used in all filling and finishing operations, except, of course, where water rubbing only is done. By-ways and corners, bench drawers and closets should be kept free from accumulations of any of the materials saturated to any degree.

Filling.—See "Finishing."

Flash Lights.—For photographic and pyrotechnic purposes. Powders similar to explosives, and similar precautions should be taken in handling and storing them.

Flasks.—The wooden or iron boxes used in moulding in foundries. Those of wood should not be stored inside so as to expose buildings, as they become charred and may harbor smouldering sparks. They are also a prey to transient sparks.

Fuel-Oil System.—These should be installed in accordance with the underwriters' requirements. In general, there are gravity, pumping, intermediate tank, auxiliary standpipe and air-pressure systems. In gravity systems the oil flows to the burners by gravity from the main supply tanks; in pumping it is forced to the burners by small pumps, the supply tanks being below the burners; in intermediate tank systems the oil is forced to small elevated tanks; in auxiliary standpipe systems the oil is pumped from tanks below the burners to standpipes, 4 to 6 inches in diameter, and tall enough to give the desired pressure, with overflow pipes at their tops draining to the supply tanks; in the air-pressure systems various procedures occur, the general plan being to pump air upon the surface of the oil in a closed tank, the pressure forcing the oil out to the burners.

An intermediate tank system of one firm is unique in that it has a small tank filled by a ball-float arrangement, the burners being a few inches above the oil level maintained and provided with two nozzles, one for air or steam and one for oil in the center of the other. The air or steam, being forced out past the orifice of the oil, produces a partial vacuum which allows the oil to rise to the nozzle where it is sprayed by the air or steam, as the case may be.

The chief desideratum in all acceptable systems is that the oil does not gravitate to the burners from any considerable supply. The piping should also be tight and be self-draining, with convenient valves. The supply tanks should be underground and well removed.

Gasometers.—In gas plants the gas is stored in huge water-sealed iron tanks. It is possible to explode them by lightning stroke or exposure to fire, and a case is known where a high wind tipped a gasometer over so that it was unsealed and the escaping gas ignited. Ordinarily, such burning does not amount to an explosion, but it is possible for the burning gas in an injured gasometer to so thin out by escaping that incoming air will produce an explosive mixture. Small gasometers for acetylene gas machines, and the like, should not be allowed inside.

Gasolene Devices.—These are too numerous for specific mention. The principal are venders' torches, lamps, plumbers' soldering-iron heaters, blow-torches or paint removers, stoves, portable lead-melting pots, pyropen apparatus, branding apparatus, etc. All are dangerous and only such appliances should be used as are approved by Underwriters' Laboratories. Paint removers, venders' torches and non-safety gasolene stoves are particularly hazardous.

Gas Purifiers.—In the manufacture of illuminating gas. They are shallow pans with false bottoms, the upper bottom being perforated. They are filled with iron filings, rusted, and sawdust, which removes the sulphuretted hydrogen and carbonic acid gases present in the gas, the result being obtained by placing an iron water-sealed cover over the pan and passing the impure gas down through the iron oxide and sawdust from a pipe which usually enters from below to a point near the top of the purifier.

The danger in a purifier is that of explosion, which may result, when the cover is removed, from an open light. It is necessary to admit air to the cover to remove it because of the atmospheric pressure on the outside when the purifier is cut off at the center seal; and an explosive mixture of the gas and air may be formed which, if ignited, may wreck the building. Obviously, only natural light or securely enclosed lights shining through a pane in a window should be permitted

Gas Stoves.—These are of various patterns. The flat, single or multiple burner type in common use has short legs to raise it from the table or floor on which it rests, but these legs do not give sufficient clearance, and if the stove rests on wood it should have protection under it. Rubber hose should not be allowed for connecting any gas stove, as it rots or becomes loose. The permissible hose is braided and stiffened by an inside coil of wire to prevent it from kinking or being crushed temporarily and thus shutting off the gas long enough to put out some burners and not others, making explosions imminent. The gas stoves and radiators in use should especially not have soft rubber tubing and should not expose woodwork, curtains, etc.

Gilding.—In picture-frame and moulding works. Gold and silver leaf are put on by first oiling the surface and blowing the leaf against it, after which brushes and rags press it to the contour of the work. The rags and refuse are subject to spontaneous combustion.

Grain Elevators.—The belt-and-bucket type of elevator is almost invariably used. The legs of these are so many flues for the spread of fire. The heads and boots are also apt to become clogged by dust, and in order to prevent this inclined strut-boards (pieces in the head of the elevator under the pulley) are provided, making the head self-cleaning. Dust accumulations in the boots may be removed by slides. Hoppers venting into the legs are sometimes substituted for the strut-boards, their sloping sides making them self-cleaning. Occasionally weighted and hinged strut-boards are used, the idea being to have them open when the weight of the dust overbalances that which keeps the boards in place. These are not reliable, however, and are rare. Some elevator heads are not enclosed underneath, and there is no danger from the strut-board, but such elevators permit a great deal of dust to escape into the building. Still other elevators have both legs in one, and no strut-board is necessary, evidently. Where chain and bucket elevators are used there is little danger from the strut-board, as the pulley is like a huge sprocket and will not permit the dust to bank up. Marine legs come properly under the head of elevators, but are not so dangerous, being tilted so often as to keep clean. However, as they are sometimes placed, they facilitate the spread of fire from the first floor to the texas, affording direct communication.

Similar elevators are used for various other purposes and the above remarks are largely applicable to them.

Grinding.—Unless thoroughly wet there is generally danger of the fine particles abraded heating spontaneously if allowed to accumulate. Band-splitters in tanneries and similar devices should be arranged with this danger in view.

Gun Testing.—The testing range should preferably be fireproof, or at least lined, on account of the wads and chance bits of flaked powder starting trouble.

Hat Presses.—This includes the steam-heated moulds and flange plates used in hat factories. They and their pipes and the sandbags for flanging should be kept free from woodwork.

Ice Machines.—The machines themselves have only the ordinary engine hazards, except that they compress a gas, generally ammonia, which may escape. (See "Ammonia.") No open lights should be allowed near the machines, as leaks, breakage of the gauge or damage to the cylinder head may cause an explosion. Ammonia becomes assimilated with oil under pressure, and in this combination is explosive.

Incubators.—These are generally wooden or glass boxes warmed by oil or gasolene lamps or stoves placed, as a rule, at one end under the mouth of a duct leading through the box. They should not be allowed in important buildings, being subject to frequent fires with either source of heat.

Ironing Machines.—In steam laundries, for ironing cuffs, collars, bodies, linen, etc. Generally rollers heated by internal gas flames; a few are steam-heated. Clearance and neatness of surroundings and connections important. Soft rubber tubing should be discouraged.

Kit Heaters.—For heating shoemakers' dressing tools. In ordinary cobbleries a rest is provided on top of the chimney of an oil lamp or stove; in factories such stoves or lamps or fixed gas-jets are used, unless the tools are on machines, in which case a small jet impinges against the tool as it operates. Stoves and lamps are easily upset and are trouble breeders, and the fixed gas-jets, being on benches, may be surrounded by inflammable materials.

Lime.—Unslaked, this should be stored in dry places, as the addition of water causes it to heat violently and set fire to the containing barrels or other inflammables near.

Machinery.—While we naturally associate with the more rapid moving machinery the idea of greater hazardousness, it does not necessarily follow that the slower moving may not in some cases be more dangerous. Great speed, of course, carries with it a tendency to heating, especially as the rapid rotation of the parts makes it more difficult to keep the bearings in oil, other things being equal; but slow, cumbersome, badly-aligned or heavily-loaded shafts may heat up to an even worse degree, since they are not self-ventilating by their speed and have more mass in which to get a cumulative heat effect. In general, it may be stated that shafting and bearings of machinery heat up as a result of poor alignment, binding or insufficient oil, any one of which defects is remediable. Shaftings and bearings of all sorts may be dangerous in other respects than as to heating by becoming oily and accumulating dust or inflammable fly or lint, and by saturating nearby woodwork. For this reason journals should never be placed on wooden beams nor the sides of wooden posts. Several makes of iron drop or post hangers are on the market and are excellent in obviating the objections pointed out. These should be adjustable, and, if self-oiling and non-dripping, are ideal. If not self-oiling, drip-cups, preferably of cast-iron and fixed substantially under the journal-boxes, should be provided. Tin cups or pans suspended by wires, so often seen, are no more than makeshifts.

It is impracticable to detail the hazardousness of every variety of machine in an article of this sort. A few general remarks only will be made, therefore.

In all machines grinding, pulverizing, or otherwise reducing substances to smaller particles by a breaking operation, considerable dust is raised and some heat is produced by the act of separating the particles from the main mass. If the substance reduced will burn, its dust will be explosive, and there is always the danger of it clogging bearings. Many such dusts in accumulations and saturated with oil can ignite spontaneously. Most machines performing operations of the sort discussed should have blowers and flues to remove the dust and collectors to prevent it from being sent over surrounding property. There is nearly always the danger of foreign particles or parts of the mechanism striking fire.

The above is true of machines altering stock by cutting and polishing operations, while those doing sorting or separating operations raise dust mainly by a species of jostling and involve the dust and bearings hazards only.

Picking machines have already been mentioned. Knitting and weaving machinery involves but slight hazard as machinery, the principal danger being the possible ignition of the stock in addition to the bearings hazard.

Spinning machinery involves the hazard of numerous small, rapidly-moving spindles which may heat at their bearings, and which are often in concealed carriages or frames, as well as considerable grease hazard at the driving mechanism.

Matches.—Match heads consist of various combinations of glue, rosin, phosphorus, amorphous phosphorus, sulphur, chlorate of potash, saltpeter, red lead, bichromate of potash, nitrate of lead, antimony sulphide, fine sand, peroxide of manganese, whiting and other substances. The bursting and separation of match heads from the stems is confined to so-called parlor matches. The bursting or chipping off of the heads is caused by improper mixing of the ingredients entering into the composition. It is liable to happen with the matches of any firm, although, as a general statement, it is true that the larger factories are more apt to have competent composition mixers, and their matches will naturally average better than those of the small concerns. The specific cause of the bursting is due to the liberation too freely of gases in the mass of the composition. While this is a scientific fact, it affords little solace to underwriters, since there is no way of telling when the conditions actually obtain which produce the bursting. In other words, we cannot tell practically until we use a match whether it was made from an improperly mixed batch of composition or not.

The separation of the heads bodily from the stems is due to the formation of what is technically known as a "teat." When the splint with the fresh globule of composition is allowed to hang too long in one position, obviously the plastic composition will sag before it dries. This sagging forms a conical-shaped teat or else the whole globule settles so that it does not engage the end of the splint firmly. When the match is struck, therefore, a portion of the head or the whole head may be broken off, and the fusing of the composition proceeds where the head has fallen. It is unnecessary to point out the dangers arising from this defect. The remedy for it lies in improved methods of drying and attention to the setting qualities of the composition. If, after the splints are dipped into the composition, they are immediately reversed and later reversed again, and so on, the composition will dry as a globule, with the splint projecting into it a proper distance. This expedient is resorted to in factories where the cause of the trouble is appreciated and the reversals are made by machinery.

Safety matches are usually made with the oxydizing agents (nitrates or chlorates) in the match-head and the phosphorus in the rubber of the box. Owing to their expensiveness they are not sold as generally as the cheaper and more readily made parlor matches. The amorphous form of phosphorus is used in them and this is not only non-poisonous but not subject to spontaneous ignition.

Malt Mills.—For grinding malt. Generally mills of the roller type, but more dangerous than those in flour mills, as the stock is apt to contain more flinty and metal particles. They should have a device to keep the space under the rolls full of ground stock, so that no explosive mixture of ground malt and air can occur. Magnets should be provided in the feeds to catch steel and iron particles, and gravity separators are advisable to arrest non-metallic foreign substances. An explosion vent to the outside air is also desirable to take up the force of an explosion. Preferably, the mill should be in a section well cut off.

Nitre Bags.—Gunny-bags in which nitre is obtained. The empty bags always have adhering to them particles of nitre and are subject to spontaneous combustion in heaps, burning fiercely.

Napping Machines.—Machines for removing the surplus nap from cloth goods. Owing to lint brushed off, the bearings hazard is increased, and if the nap contains cotton it flashes readily.

Oiling Stock.—In cotton and woolen mills the stock is oiled before it goes to the pickers by scattering oil over the stock as it lies spread out on the floor. The latter should be covered with metal or be of brick or cement, as wooden floors become saturated.

Oiling Woodwork.—This generally appears upon woodwork which is to be left practically with its natural finish. It is done by rubbing the oil on with rags, applying it with brushes or dipping the object into a vessel of oil. Care should be taken with the rags and overalls or old clothes of the workmen. Considerable oil is apt to be spattered around, and adjacent woodwork should be metal-clad if possible. see also " Painting."

Oils.—These are a hazard in that they furnish fuel for a fire, and are, in many cases, subject to spontaneous combustion when subdivided on waste, clothing, etc. All animal and vegetable oils are subject to spontaneous heating under some circumstances, but the admixture with them of mineral oils of twenty to fifty per cent prevents this heating. Experiments have shown that on cotton-waste in a chamber heated to 130 to 170 degrees, boiled linseed-oil ignited in 1¼ hours, raw linseed-oil in 4, lard-oil in 4, colza-oil in 6, olive-oil in 5, sperm-oil in 4 and castor-oil in 24. See also " Painting."

Oily Waste.—Oily waste is a hazard in that it is inflammable and may ignite spontaneously. It is generally used with mineral oils in connection with metal workers and with animal or vegetable oils in woodworkers. The mineral oils may be adulterated, however, and it is always well to keep oily waste in standard cans.

Painting.—Paints consist of pigments and oils, generally turpentine, rosin spirit, rosin-oil, linseed-oil and benzine. In many cases the various prepared ingredients are mixed as needed, being kept on hand for the purpose. Of the solid substances used, those of significance, owing to their inherent or indirect hazardousness, are lamp-black, the chromes, Prussian blues, vegetable blacks and sometimes red lead. These are all more or less subject to spontaneous combustion, or inflammable under various circumstances, and should be kept in metal receptacles or in a safe place. Lamp-black often contains unburnt oil, accounting for its liability to spontaneous heating in addition to the natural avidity of carbon for oxygen.

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Even where it does not contain such oil the accidental addition of oil to it has in many cases promoted dangerous heating. In fact, oily finger-marks upon the paper of the ordinary commercial packages have brought about undue activity of this sort. Many of the pigments made from organic substances are very inflammable when finely subdivided or ground with an oxidizing substance in a dry state, so that it is advisable not to have open lights near any apparatus apt to give rise to dust particles.

Turpentine, so general in painting, is very inflammable, flashing 97-101 degrees F. Although popularly supposed to be exempt from danger of spontaneous heating on waste, it absorbs oxygen rapidly enough to cause fire in rags saturated with it. Rosin spirit, used as an adulterant and substitute for turpentine, has the same flash-point and characteristics as that oil. The characteristics and behavior of benzine are well known. Linseed-oil, particularly boiled, has great avidity for oxygen, and is especially subject to spontaneous combustion in conjunction with rags, waste, etc. If dissolved in turpentine, as in paints, the tendency to heating is magnified, so that painty rags are even more dangerous than those saturated with the oil alone. The flash-point of linseed-oil is high, however, so that there is little danger from the oil at ordinary temperatures, except that from spontaneous heating on waste.

In estimating the painting hazard, it should be borne in mind that higher grade work carries with it, on the average, more skilled and, consequently, careful labor. In coarse work, also, there is not the same necessity of care with the materials used, from the standpoint of economy, as in the case of high-grade work, and the natural carelessness of the laborers is enhanced by this fact. It is a fact, also, that all labor is unconsciously affected by the degrees of care essential in the commercial use of its services, and, in connection with painting, this physico-moral feature is probably most significant.

Where any considerable amount of oiling, painting or dipping is done, iron closets, properly raised from the floor, ventilated and free from the proximity of inflammables, should be provided for the clothing and overalls of the men. Both heavy wire grating and sheet or corrugated iron closets are made for this purpose, each having many points of excellence. Where sprinklers are installed, the grating closets are, on the whole, preferred by the writer; otherwise, the solid-walled. Wooden closets are very objectionable. Even if lined with tin they are not so good, and cost nearly as much as the iron. The practice of hanging clothes and overalls on wooden partitions, or together in a large dressing-room, should be discouraged, and throwing them in heaps on or under benches entirely discountenanced. Nor should wooden receptacles of any kind be used for oily waste, wipes, rags for cleaning smeared hands, etc.; iron boxes with legs about 3 inches long and self-closing lids are the best and safest.

The scope of this article is too limited for extended comments upon paint and oil storage, and only a few remarks will be made. Only a day's supply of materials should be permitted inside the main buildings, and any remaining stock should be removed to the storehouse or vault at the close of a day's work. Cans containing volatile oils, such as turpentine and benzine, should not be allowed to stand around without stoppers, especially if partly empty, as the space above the surface allows an accumulation of the fumes to occur. Painters should not be permitted to "try" their brushes all over the walls of partitions or closets. The main supply room, if inside, should be fireproof and so constructed that a fire could be smothered by closing the doors to the room. It is best, however, to encourage the use of a detached building for the storage of oils, paints, varnishes, etc. Explosions may shatter an inside vault so that it would not confine a fire.

Paint Mills.—These are generally buhr stones or steel mills of similar design. They may heat and cause trouble by igniting the stock, although heating is guarded against, as it has a deleterious effect upon the paint.

Peanut Roasters.—The larger ones are similar to coffee roasters (q. v.). Venders' roasters are small, rotating metal cylinders, generally heated by a gasoline torch.

Pickers.—These, in general, are devices through which the stock passes and is torn up or loosened and straightened out by means of rotating toothed cylinders. They are of various designs, for diverse uses, and found in several classes of risks. The main hazard in all is the danger of striking fire on foreign particles and igniting the stock. Other hazards are due to friction at the bearings and the possible escape of light, fluffy material, these hazards varying in seriousness according to the kind of machine and the stock worked. Regular pickers for cotton or easily inflammable goods should vent to fireproof rooms if they are inside. The individual characteristics and degrees of hazard in pickers are too numerous to mention here. The principal pickers or machines doing picking operations are blowers (hat factories), buhr, cards, devils (hat factories), dusters, excelsior, garnettes, gins, grabot gins, hair, lappers, linters, mixing, openers, rag, waste and willowers.

Pouncing.—An operation in felt and wool hat-making, corresponding to napping, in which the hat body is placed on a rotating block and smoothed with sandpaper. Considerable lint arises, clogging bearings and filling cracks and corners. Blowers should be provided to remove it.

Printing Presses.—The hazard in connection with these is due to the grease and oil which in time saturate the floor, the steam-pipes, sometimes installed under them to regulate the consistency of the ink, the rags and waste used in cleaning, the possible use of benzine in washing forms, type, rollers, etc., and the making of rollers. The floor under all presses, unless brick or cement, should be metal-clad, and safety waste and benzine cans provided. In newspaper work, where high speed rotary presses are used, to reproduce half-tones a quick drying ink is used, generally thinned with benzole; the vapors liberated make this process very hazardous. Good ventilation is necessary and provision must be made to take care of static electricity on the paper.

Quick-aging.—Whiskey is aged principally by tannic acid in the staves of the barrels. It is hastened sometimes by steam, generally from coils around the rooms. There is no special hazard when it is done this way, except that the evaporation is hastened and there is a possible chance for the fumes of evaporation to accumulate and result in fire on the careless entry of open lights into the room.

There are methods, however, which may result in the bursting of the barrels, unless extreme care is exercised. They involve the rapid heating of the whiskey, usually by inserting a goose-neck steampipe in the bunghole of the barrel.

Rolling Mill Rolls.—These have a squeezing effect upon the hot metal, causing confined gases to be compressed and explode, and throwing scale and small particles sometimes 100 feet. They should have good clearance to woodwork and corners containing waste, overalls, etc.

Rubbing.—See "Finishing."

Rubber-Cement.—Also guttapercha-cement. Cut with benzine and should be used from safety-pots only. The best of these are similar to pneumatic chicken watering-troughs.

Screw-cutting.—Where "soda water" is used, screw-cutting involves no hazard. Oil is frequently pumped over the work or run over it from cans or small tanks, and there arises the so-called "grease-hazard," oil being necessarily scattered on the floor until it becomes saturated. Heavy mineral oils are used for the purpose, and there is no danger of saturated rags igniting spontaneously.

Setting.—In tanneries. Grease is worked into the leather by slickers as it lies stretched upon tables. Excess grease should not be allowed to accumulate.

Shafting.—See "Machinery."

Shavings Vaults.—Shavings vaults or rooms are designed to reduce hazard and do so, inasmuch as they confine shavings and dust to certain limits, but they involve hazards, perhaps, not suspected at first. Not the least of these is that of explosions which occur in the dust-laden air of partially filled vaults when an open light or flame is introduced in any way. Dust explosions and their causes have been explained elsewhere. The necessary flame or spark can be furnished in various ways—from hand torches near the opening, lanterns, coals from a back-draft, electrical mishaps, etc., and shavings rooms or vaults should be so arranged as not to damage main buildings if shattered by explosions or destroyed by fire. If inside, they should be absolutely fireproof and should have safety vents to the outside air. It may be well to add that these vents are to relieve the force of an explosion, and may be arranged with flap-checks, so as to remain shut against the mild expansion of gas resulting from ordinary burning inside the vault, so as to smother an ordinary fire. The doors to vaults, bins or rooms should not be in line with a back-draft from the boiler furnaces or too near the latter if to one side, and should be arranged so as to close easily. A wall of the bin, room or vault also should not form a part of the boiler setting, owing to the cracks which are apt to form in the latter, and if the structure adjoins the boiler or engine rooms its walls toward them should be continued through the roof as a parapet.

Shellacking.—Hazard is due to the presence of alcohol which is used to dissolve the shellac.

Singeing.—In bleacheries and cloth works the nap is singed off in some instances by gas flames, the cloth passing rapidly over the latter. Rooms in which this is done should be cut off, as the interior is dried out and any hitch in the feeding apparatus would result in the cloth being ignited. Hats are singed by flaring gas flames after being pounced, the hazard being that of open gas flames only, as a rule. The same is true of pigs' feet, ear and snout-singeing in packing houses.

Smoking.—The hazard of smoking is due to careless use of matches and disposition of the discarded remains of a pipe-bowl, cigar or cigarette, as well as to the ignition of inflammable vapors.

Squeezers.—For welding together the molten particles of puddled iron. Spark and scale hazard prominent.

Static Electricity.—Reference is made only to such as is generated by belts, moving machinery, rubbing of brushes against stock, etc. Small sparks frequently jump through the air and can ignite inflammable vapors in the air or fine lint and dust. In some cases grounds can be provided to reduce the static charge, but in many cases the development of static electricity is difficult to foresee and prevent.

Straw and Hay.—Used for feed, bedding, packing, collar-stuffing, etc. Hazard due to its ignitability and combustibility. It should not be strewn about inside of buildings. If its presence be necessary inside buildings it should be stored in metal-lined or tile-walled bins with doors. Sometimes subject to spontaneous combustion.

Transferring.—In lithographing establishments the designs are transferred from paper to the stone, turpentine and rags being used in the cleaning operations. Such rags should be kept in standard cans.

Trimming and Upholstering.—These occur in carriage, coffin and furniture factories and similar risks, and the hazard is due to the large amount of tow, excelsior, moss, hair, cocoanut fibre, shucks, cotton, etc., used, as well as the presence of glue-pots and flat-irons occasionally. Bins should be provided for superfluous stock at night and a regular daily sweeping made. Stove heat and oil stoves in the vicinity are dangerous.

Trip Hammers.—Spark and scale hazard. If operated by steam, steam-pipe hazard also. Some trip hammers are raised by friction belts, and a small hazard exists at the belt and pulley.

Varnishing.—Varnish is usually applied with brushes. Cheap work is frequently dipped. There is little hazard in the actual application of varnish with brushes, although it is said that frictional electricity is sometimes generated in slapping the brushes around and sparks have ignited the fumes or vapor from the ingredients in the varnish. The real hazard lies in the use of materials of an inflammable and more or less volatile nature, also subject to spontaneous combustion when spread thin on rags or waste. In fact, the hazard of varnishes is practically the same as that of their constituents, boiled linseed-oil and a volatile solvent, except that varnishes containing turpentine and linseed-oil are even more subject to spontaneous heating.

Vulcanizers.—Generally steam-heated vessels, chests, cylinders or arms. Hazard that of steam-pipes. Smaller vulcanizers are sometimes gas-heated.

Zapon.—A lacquer cut with amyl-acetate and consequently inflammable and explosive. Similar lacquers pass under the names lustrine, brassoline, opaline, Egyptian lacquer, etc.

Xylonite.—Practically the same as celluloid (q. v.). Sometimes spelled zylonite.

PLANNING AND ARRANGEMENT OF HAZARDS

The Chicago Board of Underwriters recommends the safeguarding of the following hazards in connection with the construction or alteration of buildings for the specific purposes as noted:

Bake Ovens.—The following specifications, with the exception of the first, are for ovens located in combustible buildings.

Ovens located on the upper floors of fireproof buildings should be supported on special foundations provided in the framing of the buildings. The wooden top flooring (and nailing strips) of the firing floor should be removed for a distance of twelve inches at the sides and back of oven and not less than six feet in front and replaced with concrete placed directly on the floor arches.

Rotary or revolving ovens are generally built on special foundations in the ground, extend up to the second floor of the building and have the firing door (through which fuel is fed) on the first floor. The firing floor (from which fuel is fed) should have joists, beams, girders and flooring removed for a space of eight feet in front of the ovens and the space filled in with I-beams and tile or brick arches; it may also be necessary to provide the same sort of clearance at sides and back, depending upon the thickness and condition of the oven walls. The charging door (through which the material to be baked is fed) is usually on the second floor and consists of a long horizontal opening extending nearly across the face of the oven, and about 18 inches high; a metal hood with metal vent pipe communicating to the outside air should be provided to carry off the heated air and gases. The tops of these ovens are usually constructed of brick arches and should be covered with sand or cinders. When the walls of the oven are extended to the ceiling of the room, a dead air space is formed between the tops of the ovens and the ceiling which should be vented—this may be accomplished by connecting the space with flues in the wall of the building and placing register openings in the front wall of the oven enclosure to provide for circulation; or by raising the flooring above the oven, about 24 inches above the main floor line and placing louvres in the bulkhead thus formed, which will allow the hot air to escape into the room; the first method is preferable and safer.

The ordinary brick ovens as found in small bakeries are generally built on the ground and do not extend through the floor. The clearing to combustible ceilings, partitions, etc., should be not less than 18 to 24 inches and wooden ceilings should be kept well whitewashed. The floor in front for a distance of 8 to 10 feet should be incombustible.

Portable ovens found in the small bakeries are built in skeleton style on iron legs and are open underneath, the fire-box and ash pit extending sometimes to within 10 inches of the floor. Although these ovens are fairly safe, it is preferable to place a metal sheet extending underneath and 6 feet in front and 3 feet at sides and back of the fire-box and on this a layer of 3-inch hard burned hollow tile or 4-inch brick on edge.

Ovens of the "Middleby" type (which have short legs) should, if located over wooden floors, have a foundation of at least 4-inch hard burned hollow tile with continuous air ducts—this is to provide for circulation of air through the tiles.

Small portable gas heated ovens, used extensively in restaurants, boarding houses, private bakeries, etc., usually have walls made double of metal with a filling or mineral wool. They set close to the floor and should have a foundation varying according to the size of burners used, but at least equal to that specified in the last paragraph. Care should be taken in regard to exposed combustible material.

Inside chimneys used in connection with bake ovens should have brick walls not less than 8 inches thick, lined with flue tiling; the throat area should be sufficient to prevent undue heating. Outside chimneys (stacks) may be of metal provided they are self-supporting and have ample clearance to combustible material.

Boilers.—The term, low-pressure boilers, will be taken under this section as meaning boilers in which the steam pressure does not exceed 15 pounds; high-pressure boilers, those in which the steam pressure exceeds 15 pounds.

Combustible ceilings over boilers should have no concealed spaces and should be protected by at least two good coats of whitewash or fire-retardent paint, which will need to be renewed as occasion demands, This means that wood or metal sheathing, plastering, etc., should be removed and the ceiling left unfinished so as to be readily accessible for inspection, whatever protection is necessary, aside from the whitewash or paint mentioned above, being placed upon the boiler.

Clearance. 1st—Between boiler and fire-proof ceiling (concrete, brick or tile arch, etc.), is not serious enough to be dealt with except in special cases. 2d—Between the unprotected arch or breeching (smoke flue) of a high-pressure boiler and combustible ceiling or material must be not less than 36 inches; may be reduced to 18 inches if the arch or breeching is covered with at least 3 inches of asbestos cement, or its equivalent—breeching should be covered on sides as well as on top; and may be reduced to 10 inches in one-story boiler houses if the arch or breeching is protected with 3 inches of asbestos cement, provided there is ample ventilation over the arch or breeching to the outside air. 3d—Between the unprotected arch or breeching of a low-pressure boiler and combustible ceiling or material must not be less than 24 inches; may be reduced to 12 inches if the arch or breeching is protected by 3 inches of asbestos cement or its equivalent—breeching should be covered on sides as well as on top; and may be reduced to 6 inches in one-story boiler houses if the arch or breeching is covered with 3 inches of asbestos cement, provided there is ample ventilation over arch or breeching to the outside air.

NOTE.—Breechings which have been in use for some years may be too weak to carry the amount of asbestos cement called for, in which case some lighter material may be specified as a substitute.

The dome of a boiler is simply a large steam holder and may be treated as far as concerns clearance, with large steam pipes, except that in case it is located between joists, or is otherwise pocketed, it should have at least a 3-inch clearance and be protected with 2 inches of asbestos cement having smooth finish.

Boilers set over wooden floors should be arranged as follows: On the floor place a sheet iron or steel plate, not less than 3-16 inch in thickness, extending at least 5 feet in front of and 2 feet on all other sides of boiler or boilers; plate to be securely riveted at joints and turned up 5 inches at edges all around; on top of the plate place at least 5 inches of brick set in cement mortar; on top of the brick cover the space directly under the boiler with 6-inch hollow fire-tile covered with 3-16 inch steel plate. (See Chimneys, Flues and Stacks.)

Brass Furnaces—*Specifications for Mounting.*—Should preferably be located only in high one-story buildings (ceiling 12 feet or more above the floor) having plain brick walls and incombustible floors. All furring on walls and the underside of roofs for a distance of 5 feet each side of furnaces to be removed. All wooden ceiling joists in immediate vicinity to be thoroughly whitewashed.

If necessary to locate in other than one-story buildings, place the furnaces on the top floor and construct the foundation for same as follows:

Installation Under Low Ceilings.—If the ceiling is less than

12 feet in height, the wooden floor joists should be cut away 12 inches wider each side than the space required for the furnace-well and framed in with 12-inch steel I-beams, properly supported; to this steel framing securely support an iron pan (not less than 24 inches deep) maintaining a 36-inch clearance between the furnaces and the combustible floor or materials. Grating used at the floor line of pan to be made of steel or iron bars. Ceiling over above setting to be removed, the roof cut away 18 inches each way beyond the line of furnaces and the opening thus formed filled with a metal ventilator.

Stack.—To be constructed of metal or brick; if of brick, to be not less than 8 inches thick and lined with fire-tile; if of metal, to be made of not less than No. 12 U. S. gauge steel (must be not less than 3-16 inch thick in the base and extending to a point 12 inches above, where the auxiliary flue connects), properly riveted and lined with 4 inches of fire-brick—lining to extend continuously from the furnace to a point at least 24 inches above the roof boards. To have at least a 10-inch clearance to roof boards if a ventilated weather shield is used, otherwise to have at least a 15-inch clearance —a separate collar or fender should be provided below the roof boards, arranged to shield the boards in the vicinity of the stack from the radiation of heat and cause the heat to pass up and around the stack through the ventilated shield above the roof. Metal stacks should never pass through floors.

Casting Floor.—Should be fireproof, but special permission may be given at discretion to use a wooden floor if same is covered with ¼-inch asbestos which in turn is covered with brick laid flat or on edge and embedded in 2 inches of sand. A special platform should be provided for depositing skimmings from the ladle, or on which to place hot ladles. This platform should be of 6-inch hollow tile or its equivalent and should be placed on the above-described casting floor unless such floor is strictly fireproof.

Installation Under High Ceilings.—If the ceiling is 12 feet or more in height, the furnace may be set above a wooden floor, provided the following foundation is used:

1st—Place a covering of ¼-inch asbestos on top of the wooden floor, covering the entire area of furnaces and extending 4 feet in front of and 3 feet beyond the sides and back of same.

2d—On top of the asbestos place a metal pan made of not less than No. 14 U. S. gauge steel with 4-inch upturned edges (all joints to be securely riveted).

3d—Fill the pan with common brick laid on edge and slushed with cement mortar.

4th—Support each furnace independently by parallel I-beams which should be laid on brick and terminate about 6 inches in front of and about 6 inches in rear of the furnace; bottom of furnace to be not less than 12 inches above the brickwork.

NOTE.—Either 12-inch or superimposed 6-inch I-beams may be used to secure the necessary height.

Place a plate (see note below) of No. 12 U. S. gauge iron or steel 6 inches above the brickwork and covering the entire area between the I-beams; this plate to be supported by flanges riveted to the webs of 12-inch I-beams to be supported on top of 6-inch I-beams and riveted to both upper and lower beams. The space between the plate just mentioned and the brickwork may be left void, or may be filled by a layer of double air-cell 6-inch hollow fire-tile set in cement mortar and well slushed at sides next to I-beams, or may be filled by a layer of 6-inch steel rails or I-beams; if hollow tile is used, the channels in the tile must be continuous, parallel with the I-beams supporting the furnace, and be kept open at both ends at all times. Ceiling over above setting to be removed, the roof cut away 18 inches each way beyond the line of furnaces and the opening thus formed filled with a metal ventilator.

NOTE.—The plate mentioned above is for the purpose of preventing the space below filling with cinders and, where tile is used, to prevent the tile being broken when the furnace is barred down. Where the box-bottom or air-chamber type of furnace is installed, the height of the chamber may be figured in the 12-inch clearance required above the brick foundation, and the heavy plate under the grate may be omitted.

The flue or auxiliary chimney leading to the main stack, if near the floor line, must always be mounted on a platform similar to the one just described for the furnace; the sides and top of this flue to be of 8-inch fire-brick and independent of the building walls (unlined metal flues or stacks are unsafe, as they deteriorate rapidly, due to the intense heat resulting from the white hot metallic dust which accumulates in the flue); must be constructed so that the air channels in the tile foundation of furnaces will be unobstructed.

Stack to be of brick or metal, as previously described.

Installation on an Intermediate Floor.—Where it is absolutely necessary to install furnaces in other than top floors or one-story buildings, the following rules apply:

1st—Foundation, casting floor and auxiliary flue to be constructed as already described, according to the height of ceiling.

2d—Stack, if in wall, to be not less than 8 inches thick, lined with fire-tile; if of iron and preferably run up on outside of wall between window bays with not less than a 3-foot clearance to inflammable material and extending at least 8 feet above the roof, to be not less than No. 14 U. S. gauge with 2-inch brick lining; if of iron run through floors, to be not less than No. 12 U. S. gauge lined with 4-inch fire-brick, surrounded by a 6-inch hollow fire-tile stack, extending 4 feet above the roof and open at top and bottom, so arranged as to allow a 6-inch clearance between the stack and tile; joists to be headed at floor openings with 6-inch I-beams carrying the tile.

3d—A hood of sheet metal, not less than No. 20 U. S. gauge at sides, and No. 16 U. S. gauge at top, to be placed over and extending 3 feet, all sides, beyond the line of furnaces; hood to have at least a 24-inch clearance to ceiling and to be connected with a pipe venting outside of building (if possible) to carry off the heat.

Converter Type Furnaces.—Converter type brass furnaces must be installed either in a one-story building or upon the upper floor of a building more than one story in height.

Foundation.—To be of dirt or other incombustible material for a radius of 15 feet about the furnace. Where on top floor, to be constructed as follows: Place a layer of ¼-inch asbestos, on top of which place sheet metal of not less than No. 14 U. S. gauge; then a layer of 4-inch hollow tile (hard burned or fire-tile preferred) slushed with cement mortar—air ducts to be continuous; on top of the tile place a layer of 2-inch brick laid in cement mortar—solid brick instead of hollow tile may be used directly under the supports for furnace.

Roof over space used for furnace should be removed for an area 20 feet square and a metal ventilator installed.

Casting floor should be similar to that required for other furnaces.

Fuel oil systems should be installed in accordance with specifications furnished on request.

Buffing Wheels.—Buffing or polishing wheels, emery wheels, and all lint, dust and shavings producing machines should always be provided with blowers preferably venting outside of buildings into a metal dust house, tank of water or other non-inflammable receptacle which would prevent the refuse collecting inside or on roof of building or adjacent buildings. When venting into a furnace or vault inside of building, an automatic damper should be provided in the discharge pipe.

Candy Furnaces.—Having 4-inch legs should be installed as follows: Place No. 16 U. S. gauge iron on the floor, covering the space necessary for furnaces and extending 4 feet in front of and 2 feet at sides; on top of this place a layer of common brick laid on edge, slushed with cement mortar; directly under the furnaces place 3-inch hollow tile (hard burned or fire-tile preferred). Furnace legs may rest on brick supports. Chimney for furnaces, if inside the building, should be not less than 8 inches thick and lined with flue tiling, or if outside, to be metal. All walls within 4 feet of furnaces to be of plain brick. If ceiling is less than 14 feet high, a metal hood constructed of not less than No. 16 U. S. gauge steel should be placed over furnace and ventilated to outside of building.

Iron Stacks.—Outside stacks should be built round of galvanized iron (not less than No. 12 U. S. gauge), properly riveted at all joints and braced about every 10 feet with band or angle iron well fastened to building wall. They should extend at least 10 feet above roofs of buildings and be kept at least 4 inches from the building wall.

Inside stacks should be discouraged; where found should be very well built and protected. They should be constructed of not less than No. 12 U. S. gauge steel and where extending through roofs and floors should be enclosed in not less than 8 inches of brick or 6 inches of hollow fire-tile, maintaining a 4-inch air space between the stack and enclosure throughout.

Stove pipes passing through closets, blind attics (and other concealed spaces) should be condemned.

Stove pipes of 6-inch or less diameter passing through floors, partitions, sides of buildings and roofs are dangerous and should be removed. If allowed to remain, they should be protected by double, metal, ventilated thimbles so arranged as to maintain at least a 4-inch clearance between the pipes and combustible material; thimbles to extend at least 3 inches at both ends beyond the surfaces protected.

Stove pipes and smoke pipes from hot-air furnaces, more than 6 inches in diameter, should be kept at least 12 inches from combustible partitions, walls, etc., and be protected by double, metal thimbles or equivalent.

Pipes mentioned in the two preceding paragraphs to be kept at least 18 inches below combustible ceilings, or else the ceilings should be protected with ¼-inch asbestos (covered with metal) or its equivalent.

Coffee Roasters.—Should be located on the top floor in a room having not less than 8-inch brick or 6-inch hollow tile walls with single standard iron doors (not less than No. 14 U. S. gauge) on openings; ceiling and floor to be brick, concrete, or tile arched, at least 8 inches thick, sprung between iron or steel I-beams; arches to be open finished underneath. Room to have approved skylights or metal ventilators.

If impossible to secure the foregoing specified floor construction, the following may be acceptable: Wooden floor to be protected by a layer of 1/4-inch asbestos or equivalent covered with sheet metal, on top of which are placed two courses of 4-inch hollow tile laid at right angles with air spaces continuous and with a top covering of 3-16 inch plate iron or steel. Cooling pans to be metal and provided with metal blow pipes. Chutes and hoppers to floor below should be metal.

Core Ovens.—Brick ovens should have at least a 3-foot clearance overhead and a 12-inch clearance at sides to combustible material; metal ovens should have at least a 3-foot clearance overhead and at sides to combustible material.

Cupolas.—Should have at least a 36-inch clearance at combustible charging floor and roof and must extend 10 feet above the highest point of any roof within a radius of 40 feet. If the charging floor is less than 8 feet above the dump floor, the former should be of fireproof construction.

Cyclone Dust Collectors.—To vent outside, or to a dust room having outside ventilation.

Corn Shellers.—To have dust pipes attached, venting outside or to boiler, except where a corn cleaner is in use, in which case may vent to the latter.

Drip Pans.—Metal drip pans should be placed under all machines using oil to catch oil drippings, metal borings and shavings, etc. The contents of these pans should be removed from the building each night in metal receptacles.

Furnaces—Soft Metal.—These are divided into several classes: Babbitt metal, stereotyping metal, electrotyping metal, lead, etc.

Stereotyping metal, being the hardest grade, requires a hotter fire and more concentration of heat under the kettle; this causes a deflection of intense heat downward, which must be provided for. A preferable foundation for this class of furnace is to remove all wooden joists, beams and floors, insert steel I-beams with either brick, concrete, or tile arches, and on top of this spread 3 inches or 4 inches of concrete and cement.

Electrotype furnaces usually have a large air space in the ash pit and rest on 6-inch legs, the metal pot not requiring the depth of stereotyping furnaces. In most cases a plate of No. 10 or No. 12 U. S. gauge steel is placed upon the floor, extending in front of and at sides as circumstances may warrant. Small metal furnaces such as are used in metal novelty works and gasket factories are usually set on 10 or 12-inch legs with a protection of metal covering the floor under and around same; a metal shield midway between the bottom of furnace and floor usually affords ample protection.

Furnaces constructed of an iron pot set in brick require special care in construction, as the pot when filled is quite heavy, requiring walls of brick to be so constructed that they will not break down or open up in the joints. The following usually makes good construction: On top of floor place sheet iron (about No. 12 U. S. gauge); on top of this place one layer of 4-inch hollow tile laid in cement mortar; on top of the tile in the space directly under the fire-box place a layer of fire-brick on edge, filling balance of space with common brick. Build the furnace enclosure wide enough to permit of a 3-inch air space between inside and outside walls. Bind walls of furnace by 3x3x¼-inch angle iron strapped together at top and bottom. Construct support for pot of 5-inch fire-brick laid flat; this forms the side or enclosure of the fire bed and ash pit; the 4-inch air space surrounds this enclosure. Outside shell to be constructed of not less than 8-inch brick. Top covering is usually an iron plate at least ½ inch in thickness. A raised wooden platform may be constructed along side of furnace to permit of the dipping out of metal.

Grain Bleachers.—*Construction.*—To be of brick, concrete or other fireproof construction, or, if of cribbed construction, to be protected on the outside by brick, concrete, metal or other incombustible material.

Location.—To be set at least 25 feet from the elevator, or from any building adjoining or communicating with elevator, unless communications are protected in a standard manner.

Spouts.—To be connected to the elevator above and below by metal spouts properly cut off by two automatic valves in each spout.

Conveyors.—All conveyors to be metal screw conveyors in metal box; no combustible material to be used between bleacher and elevator.

Furnace.—Sulphur burning furnace to be set at least 25 feet distant from bleacher in the opposite direction from the elevator; to be of fireproof construction; to be unenclosed, except it be an enclosure of fireproof construction.

NOTE.—When necessary to set furnace closer to bleacher than above specified, it may be done provided the fume pipe is not less than 25 feet in length.

Japan or Enameling Ovens.—Japan ovens are mostly constructed of metal, except in large plants where special buildings are constructed for the purpose, in which case they are built of brick usually outside of an opening through iron doors into room where the japan dipping is done. Steam, gas and coal fires are used to heat these ovens. Steam heat is not conducive to rapid or hard drying and is being dispensed with, except in the smaller plants.

Gas heat is used by placing parallel perforated pipes on metal supports about 4 to 6 inches above the floor, the heated air passing up to the top and down the sides to a ventilator which extends to the outside of the buildings. Coal fires are sometimes built in an open ditch inside of the oven (this applies to brick ovens), and others have a stove recessed into side or set in the room. Owing to the nature of the thinner used in japan and enamel, the vapor thrown off in the process of drying is liable to ignition where an open fire is used. This hazard may be reduced somewhat where good ventilation is provided. Foundation under large japan or enameling ovens should be not less than 6-inch hard burned hollow tile with ducts laid continuous, and wooden flooring should be covered with metal between front of oven and dip trough to prevent floor being soaked with oil.

Small lacquering ovens are usually made of metal, have a low temperature and are mostly steam (a few are gas) heated; these are usually set on legs, but where they are not, it is well to place 4-inch hollow fire-tile under same.

Brick japan or enameling ovens set on any floor above the basement should have foundations of brick or tile arches on steel I-beams, and doors to same should be not less than No. 14 U. S. gauge. In plants where a number of metal japan or enameling ovens are used, a fireproof room should be provided on the top floor with thin glass skylights and ventilator; opening to room to be protected by No. 12 U. S. gauge self-closing doors. This latter plan applies to nearly all large plants where a separate building is not feasible.

Packing Material.—To be kept, when loose, in wooden, metal, or tin-lined wooden boxes with automatic or self-closing covers.

Pickers.—In ordinary buildings, pickers for moss, hair, excelsior, etc., should be in a room used exclusively for this purpose and having a window or other outside ventilation. Sides and top of room to be of incombustible material, such as metal lath and plaster on metal framing; or double sheet metal with hollow space of at least 1 inch; tile or its equivalent may also be used. Floors to be made of 2-inch tile or cement, or their equivalent, and covered with sheet metal. The only communication from the room to the building to have a good self-closing door equivalent to the construction of the sides of the room; any openings for stock spouts, etc., to have automatic doors. Automatic sprinklers to be installed, or a live steam jet to be put into the room with valve on outside, or an approved chemical fire extinguisher to be kept just outside of door leading to the room and a small protected hole provided for inserting the nozzle of the extinguisher.

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Paint Mills and Printing Presses.—To be set on metal-clad or incombustible floor; surroundings to be kept neat. (This also applies to other oil-bearing machines.)

Pressing Irons and Heaters—Protection Under Same—*Gas Irons*—(a) Where possible to obtain, especially in shops using more than ten irons, iron tables should be provided.

(b) If wooden tables are used, protect same with ½-inch sheet asbestos covered with sheet iron (not less than No. 16 U. S. gauge), both extending at least 2 inches beyond all sides of iron stands; iron stands having not less than 3-inch legs to set on top of sheet metal and to be securely fastened to table; but not to have the legs extended through the sheet metal or asbestos.

(c) Gas, air blast, pressing irons to be provided with iron stands having legs not less than 3 inches long.

All gas supplies to pressing irons to be provided with shut-off valve, or valves so arranged as to cut off the entire supply; valves to be closed every night.

Gas Plates.—If used over wooden tables, should set on 3-inch hollow tile, have at least an 8-inch clearance to combustible material at sides and back and never be located under wooden shelving.

Electric.—(a) Must each have a cut-out and an indicating switch.

NOTE.—It is often desirable to connect in multiple with the heaters, an incandescent lamp of low candle power, as it shows at a glance whether or not the switch is open, and tends to prevent its being left closed through oversight.

(b) The base of iron must be set on iron or other incombustible stand in such a manner as to maintain a 3-inch clearance between bottom of iron (when in place on base) and combustible material beneath.

Coal or Wood-Heated Busheling Stoves.—If used over combustible floors, should be set on 4-inch hollow fire-tile on a layer of brick (on edge, well laid in cement; brick to extend 3 feet in front and 18 inches at sides and back beyond line of stoves).

Ranges—*Coal.*—Coal ranges having 4-inch legs, warming oven below the baking oven and a large ash pan under fire-box, need little attention, except as to surroundings—the floor may be protected with a zinc board or sheet zinc extending 14 to 18 inches in front and 4 inches at sides and back. Where the range is set closer than 18 inches to a furred wall, the furring, wooden lath and plaster, etc., should be removed for a distance of 12 inches each side, and 6 feet above top line of range. If stud or wooden partition at back, a wall of 3-inch hollow tile should be constructed between range and partition; tile ducts to be continuous and open top and bottom; sides, if exposed within 24 inches, to have like protection. Where a coal range is of the 2-fire or 3-fire, etc., type, a foundation of 3-inch or 4-inch hard burned hollow tile should be placed on top of zinc; ducts to run the short way of range.

Single coal ranges without warming ovens below, over wooden floors, should be mounted on a foundation of 5-inch hollow tile on metal; if 2-fire or 3-fire, etc., foundation should be 4-inch brick laid in cement mortar covered with 4-inch hollow tile, brick to extend 4 feet in front of range.

Gas.—Gas stoves may be divided into three classes;

1st—Plate or single-burner. Ordinarily found in tailor shops and under coffee urns, etc. A foundation of 3-inch hollow tile should be used except where used for heating small irons, when zinc should be placed on top of board foundation and sheet iron plate suspended directly under burner midway between top of stove and table or support; or further, the table may be cut away directly under the burners.

2d—Ordinary house stove. Sometimes used in small restaurants and usually set on a perforated base or 2-inch legs. This class of stove, if in a dwelling, needs only zinc under it, but if in a restaurant, it should be protected with a foundation of 3-inch or 4-inch hard burned hollow tile; clearance at sides and back to be the same as for coal stoves.

3d—Gas ranges. This type is usually found in the large restaurants and hotels. The foundation generally required for this class is: A sheet of metal, preferably not less than No. 16 U. S. gauge, over space for range and extending 4 feet in front and 12 inches at sides of same (edges may or may not be turned up 2 inches to form a pan); on top of the metal, a foundation of 4-inch brick laid on edge and pointed up with cement and mortar—this brick foundation to extend from wall to 4 feet in front and 12 inches at sides of range; on top of brick and directly under range, a foundation of 4-inch hard burned fire-tile; ducts to extend the short way of range. Clearance from partition and combustible material, the same as for coal stoves.

Rendering Kettles.—Fire heated rendering kettles, oil boiling kettles, etc., should set on an incombustible floor; if set on legs over a wooden floor, the floor should be protected by at least one layer of brick dished toward the center, well set in cement, covered with 2 inches of cement and extending 3 feet on all sides.

The safest form of kettle is one set in brick walls, so arranged that in case it boils over the contents cannot reach the fire or flames; such a kettle is fired from the outside.

A supply of wet burlap bags provides a good means of smothering oil or grease fires. Covers provided with long handles should be kept hanging on the wall nearly, convenient for use in case the kettle catches fire.

Soldering Iron Heaters.—If charcoal or gas pots are used over wood, they should be set on at least 3-inch hollow tile or on sheet metal and asbestos with a 3-inch hollow space below.

If electric heaters are used, to be arranged so as to provide protection equally as good as required for electric pressing irons.

Gasoline plumbers' pots should be free from leaks; gasoline to be well cared for.

Stoves.—Ordinary coal or wood heating stoves set on wooden floors, should have sheet metal underneath and extending at least 18 inches in front. Protecting metal screens should be used where inflammable material is liable to come in contact with stoves.

Gasoline stoves to be of approved type.

ELECTRICITY

With the first introduction of electricity into every-day use for lighting and power, few safeguards were provided and little care taken with the installations. As a result many fires occurred and it became recognized as a distinct hazard and in many cases its use was prohibited in an insurance policy or an increase made in the premium charged. For some years the insurance interest, in connection with manufacturers, contractors and the various electrical societies, have drawn up, with revision every two years, a set of rules covering the installation of electric wiring and apparatus and the construction of fittings. These rules are known as the National Electrical Code, and are accepted as standard by practically all city electrical bureaus, as well as the underwriters. The code consists of a pamphlet of about 200 pages and is therefore not printed herein; copies can be obtained by applying to the National Board of Fire Underwriters, 76 William Street, New York City.

For the inspector or the electrician, an intimate knowledge of the code is necessary. For the owner of the building no general rules can be given, except that all repairs, changes and renewals be made by a skilled electrician and every installation looked over by a properly qualified inspector after all changes.

For the owner or architect, it is recommended that a clause be inserted in any contract "that all electric wiring and fixtures be installed in accordance with the National Electrical Code," and that during and after the installation, a careful inspection be had by an electrical inspector of the municipality or the insurance board having jurisdiction.

Electrical Fittings.—In the foreword of the code, it is stated that the portion of the rules relating to the design and construction of appliances is but a partial outline of requirements. A device which fulfills the conditions outlined, and no more, will not necessarily be acceptable. All appliances should be submitted to the Underwriters' Laboratories for examination and report before being introduced for use. A list of electrical fittings is issued by the National Board of Fire Underwriters, covering devices and materials which have been examined and are suitable for the use intended. This list is revised semi-annually.

It is best for an owner or architect to specify that all material and fittings bear the Underwriters' label and that this requirement be religiously lived up to. Much of the material installed several years ago would not to-day pass the approval of the Laboratories, and the natural deterioration of insulation and working parts also makes an old equipment sub-standard. For this reason, where a competent electrician is not employed to keep the system up, a complete reinspection at least every two years should be obtained from the municipal or the Underwriters' inspector.

Avoid Short Circuits.—In all electric work, conductors, however well insulated, should always be treated as bare, to the end that under no conditions, existing or likely to exist, can a ground or short circuit occur, and so that all leakage from conductor to conductor, or between conductor and ground, may be reduced to the minimum.

In all wiring special attention should be paid to the mechanical execution of the work. Careful and neat running, connecting, soldering, taping of conductors, and securing and attaching of fittings, are specially conducive to security and efficiency, and are strongly advised.

Installations Should be Accessible.—In laying out an installation, except for constant current systems, every reasonable effort should be made to secure distribution centers located in easily accessible places, at which points the cutouts and switches controlling the several branch circuits can be grouped for convenience and safety of operation. The load should be divided as evenly as possible among the branches, and all complicated and unnecessary wiring avoided.

The use of wire-ways for rendering concealed wiring permanently accessible is most heartily endorsed and recommended; and this method of accessible concealed construction is advised for general use.

Architects are urged, when drawing plans and specifications, to make provision for the channeling and pocketing of buildings for electric light or power wires, and also for telephone, district messenger and other signaling system wiring.

Although not obligatory by the code, it is best to make any extensive installation entirely in conduit. In many of the codes adopted by municipalities, it is required that all wiring in certain classes of buildings or within the fire limits be entirely in conduit.

SUGGESTIONS FOR PROTECTION AGAINST LIGHTNING*

Protection against lightning is usually advisable on country buildings, on isolated buildings, and on all buildings wherever located having elevated features such as tall chimneys, steeples, high peaked or gable roofs and flag poles.

Since the amount of protection which any building should have will depend upon its location, construction, nature of its occupancy, and the value of the building as compared with the expense necessary to provide the protection, definite rules cannot be laid down for the installation of lightning conductors, but the following general suggestions should, if carried out, give under most conditions, reasonable protection.

The ordinary condition causing a lightning discharge is a cloud charged with electricity at a greatly different potential from that of the earth. The difference of potential is finally sufficient to "break down" the stratum of air between earth and cloud, and an electrical discharge takes place. The resistance of the air stratum being generally less between cloud and tops of buildings and other structures than between cloud and earth, such high points take the discharge, and unless some less resistive path is provided from these points to the ground than the structure to be protected, the lightning will follow the next best course to earth, generally causing damage to the structure and frequently starting a fire.

It is also of importance to note that the discharge leaves a column of heated air between earth and cloud. This hot air column may be blown in one or another direction and very likely become the path of a second discharge, since it has less resistance than the surrounding cooler air. This may account for lightning striking a structure below the high points.

It is therefore desirable to so locate the conductors forming the lightning protection that the lightning will strike these and be carried to earth instead of tearing through the structure on its way to the ground. Such an arrangemen of conductors suggests an enclosing cage with the bars of course considerably separated. The idea of protection is therefore a metallic cage with air terminal projections at the high points of the structure and the whole protecting cage thoroughly grounded. Just what material is employed is not of great importance provided it has good electrical carrying capacity, is strong, can be bent and jointed readily, and is not liable to be seriously affected by corrosion. Undoubtedly copper in tape form or ordinary galvanized iron pipe best meets these conditions.

Just how far apart the conductors should be will depend very considerably upon conditions, and no general rule can be given for the number of square feet of ground area protected by one rod which will safely cover all cases. Since in addition to the high points the most exposed parts of a structure are the outposts and projections, extra protection is needed here, while a much wider spacing of rods might be sufficient along the sides of the structure.

In general, all-metal buildings, metal chimneys or stacks, need only to be grounded.

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* Issued by the National Board of Fire Underwriters, 1913.

GENERAL SUGGESTIONS APPLYING TO ALL STRUCTURES

NOTE.—Either copper or iron is satisfactory for conductors. One advantage of iron over copper is its higher fusing point, but iron should not be used in locations difficult of access where corrosion is likely or possible, owing to the necessity of frequent painting to guard against such corrosion.

a. CONDUCTORS.—1. Conductors when made of copper to be soft-drawn in the form of either tape or stranded cable. Except as noted below, the conductor in each case to weigh not less than six ounces per foot. Where cable form is used, no single copper wire to be less than No. 12 B. & S. gauge, while if tape form the thickness to be not less than 3/32 inch.

With copper conductors having a total weight of six ounces per foot, and the above dimensions, the cable will contain 19 No. 12 wires and the tape will be one inch wide by 3/32 inch thick.

When used on residences, barns, stables, stores and similar buildings where the maximum height of any point does not exceed 60 feet, and where corrosion is not liable to occur to any extent, copper cable to weigh not less than three ounces per foot, no single wire being less than .046 diameter.

2. Conductors when made of iron to be in the form of either heavy tape or pipe. The tape conductor to weigh not less than 1¼ pounds per foot and to be not less than 3/32 inch thick. If pipe is used the standard weight of ¾-inch pipe would be satisfactory. Iron used in any form should be thoroughly galvanized to prevent corrosion, and may also be painted if desired.

Heavy tape is specified to guard against the use of a thin sheet which would be more easily destroyed by corrosion. Pipe is specified as an alternative for the tape as it is cheaper, is readily obtainable, and can be easily installed using the ordinary pipe fittings. The fittings should, of course, be galvanized as well as the pipe, and all pipe ends and unused outlets on fittings should be tightly plugged in order to prevent the entrance of moisture inside the pipes.

3. Conductors to have as few joints as possible, these to be mechanically and electrically secured and to be protected from corrosion.

It is essential that the conductors be continuous and, therefore, the fewer the joints and the better these are protected from corrosion, the less chance of crippling the protection due to a break in the conductors.

4. Conductors never to be insulated but to be fastened securely in place, suitable allowance being made for expansion, by clamps of same material as conductor, the vertical rods being carried a sufficient distance from the wall to avoid sharp bends around projecting masonry or brick work. In all cases as straight a run as possible should be provided and the conductors should incline downward. The conductors should never be run through iron pipes.

Sharp bends and loops in an upward direction are liable to cause the lightning discharge to leave the conductors at these points, and as these side flashes may be dangerous, care should be taken that the conductors should run as straight as possible. Since the effect of the lightning discharge in the conductors is practically the same as that produced by an alternating current, it is obvious that the conductors should not be run through iron pipes which would tend to choke back the discharge due to induction in the pipe.

5. Conductors to be run as far as practicable from interior piping.

If the conductors are run too near the interior pipe system, there is a chance that the discharge may jump from the conductors to the pipe, and in doing so, start a fire. The best way to avoid this is evidently to keep the two systems as far apart as practicable.

b. AIR TERMINALS.—To be solid, not less than ¾-inch in diameter except on residences, barns, stables, stores and similar buildings where they may be of tubing not less than ⅝-inch in diameter with wall thickness not less than .031 inch. Terminals to extend not less than 18 inches above the point protected.

The distance of 18 inches specified is the minimum for smaller buildings. On larger buildings it is desirable to have the rods longer.

c. CONNECTIONS TO METAL WORK OF STRUCTURES.—1. All exterior metal work, such as metal roofs, gutters, ventilators, railings, chimney hoods, etc., to be connected with the lightning rod system below the line of the metal work itself or to be separately grounded by regular conductors.

Unless all such metal work is well grounded the discharge is liable to jump from this part to other conducting parts and possibly set fire to intervening combustible material.

2. All interior masses of metal such as girders, beams, water piping and any structural iron or steel, though under no consideration gas piping, to be securely connected to the system at their highest and lowest points, the connecting bonds being the regular conductor.

This suggestion is made for the same reasons as that regarding exterior metal work. (See Section c-5 preceding.)

The electrical resistance of pipe joints may occasionally be sufficient to permit a high voltage current melting the pipe at that point, which would be especially dangerous in case of gas pipes, for the arc would probably at the same time ignite the escaping gas. The same result might be obtained by arcing between the gas pipe and other conductors which might be carrying a lightning discharge. It is therefore best not to connect gas piping to the lightning rod system, as this might be the means of leading the discharge on to these pipes where otherwise they might not be affected.

It, however, would be advisable to securely bond around the gas meter the iron pipe on both sides of the meter, being careful to make secure electrical connections between the pipe and the bond.

NOTE.—A permanent and reliable ground is absolutely essential, and by far the best ground can usually be secured by connection to underground metallic water piping. When this is impracticable, ground plates, driven pipes, or the equivalent are recommended.

d. GROUNDING.—1. Connection to piping to be made preferably by soldering the conductor into a brass plug and forcibly screwing the plug into the pipe fitting, or, when the pipes are cast iron, into a hole tapped into the pipe itself; or, by sweating the conductor into a lug attached to an approved clamp and firmly bolting the clamp to the pipe after the rust and scales have been removed.

In the case of a farm building having a well outside and a pump suction pipe running to the building, a reasonably good ground may be obtained by connecting the conductor to the pipe, provided the pipe at some point is in earth below permanent moisture level.

The idea is to get as good and permanent connection to the underground piping as possible, and one that will best withstand the effects of corrosion. It is desirable to connect to two or more lengths of pipe in order to guard against crippling the protection by injury to or deterioration of a single connection.

2. Connection to ground plates to be made by riveting and soldering, and the connection to be thoroughly protected against corrosion by painting. The ground plates to be of copper and not less than No. 16 Stubb gage about 3 feet square and buried below the permanent moisture level with about two feet of crushed coke or charcoal above and below it.

A heavy iron casting having a superficial area of at least 12 square feet could be used in place of the plate. The conductor should be connected to the casting by riveting and soldering, and the casting buried the same as the ground plate above described.

3. Connection to driven pipe to be made by soldering the conductor into a brass plug and forcibly screwing the plug into a coupling on the upper end of the pipe. The lower end of the pipe to be well below permanent moisture level.

A ground plate or a driven pipe properly put into the ground is undoubtedly the most satisfactory alternative for the underground water pipe system, but is not advised where the pipe system ground is available.

TALL CHIMNEYS, STACKS, STEEPLES AND SIMILAR STRUCTURES

a. Two or more main lightning rods equally spaced about the structure to be provided, extending from the top by the most direct course to the ground.

The proper number of rods in any given case will vary somewhat with the conditions. For example, a flag pole would not require more than one rod, while chimneys 150 feet or more high should have one rod for each 50 feet of height. The higher the chimney the greater the cross sectional area at any given distance from the ground, and the additional rods are desired in order not to expose too great an unprotected vertical area to a discharge.

b. To have a band of copper or iron not smaller than the lightning rods around the top with air terminals securely attached thereto extending 3 feet above the highest point. The air terminals to be placed at intervals not exceeding 4 to 6 feet around the circumference of the band.

c. Additional bands to be provided around the structure at or near the ground line and at intervals of 25 to 50 feet, all such bands being securely connected to the lightning rods.

In the same way that additional vertical rods reduce the size of the unprotected vertical areas, these additional bands limit these areas horizontally. The bands also serve to connect the rods together at frequent intervals, so that an accidental break in one rod is not liable to be as serious as might otherwise be the case. In other words, the vertical rods are thus made to connect in combination rather than separately.

STRUCTURES OTHER THAN CHIMNEYS, STEEPLES ETC.

a. Two or more lightning rods should be provided extending from the top by the most direct course to the ground, so spaced that they will not be over 50 to 75 feet apart.

The proper number of rods and their exact spacing will depend very largely upon the conditions, such as shape of structure, the exposure with reference to both severity of lightning storms and direction from which these storms usually come. In general the most exposed parts of a structure are the outposts and projections, and here it would be advisable to place the rods somewhat nearer together than along the sides of the structure. In general it would not be advisable to carry the rods through the center of a structure, for if for any reason it becomes broken it would be the direct means of carrying the lightning to a point inside the structure where it would be almost sure to set fire.

b. Horizontal conductors to be provided connecting the vertical rods along the ridge or any suitable position on the roof and at or near the ground.

The horizontal bonding of the vertical conductors is desirable for much the same reasons as given for the horizontal bands arounds chimneys, and these horizontal conductors serve to tie the system together, thus carrying out the idea of a protecting cage. It is considered important that at least the upper and lower ends of the vertical rods be thus connected, and in general intermediate bonding would not be necessary except possibly for very high structures.

c. The upper horizontal conductor should be provided with air terminals at intervals of 20 to 30 feet, and in addition, air terminals connected with the horizontal conductor to be provided for gables or other projections above the top of the main structure. Air terminals should in all cases extend well above roofs or chimneys and be firmly secured in an upright position.

Air terminals assist in diverting the lightning discharge to the lightning rod system, and therefore it is an advantage to have them placed at fairly frequent intervals.

d. Where trees stand so close to a building that branches overhang or approach very close to the roof, a conductor with proper earth terminal to extend along the trunk of each of several such trees to the highest branch top fastened by a band around the branch or trunk, would probably give all necessary protection under average conditions. It, however, would be advisable to connect these rods together at the bottom by a substantial conductor laid under ground.

Care should be taken to protect as far as possible this underground bond connection against corrosion. Probably well-galvanized ¾-inch iron pipe, or copper in tape form, would best serve the purpose.

The above method might be used for the protection of trees wherever located.

PYROXYLIN PLASTICS OR NITRO CELLULOSE

What is Nitro-Cellulose?—To the public the name celluloid is generally thought to include all pyroxylin plastics and even in official publications of the British Government, the general term of celluloid is used; this however is a trade name of the product of a single firm and for this reason it will not be used in this book.

Commercial pyroxylin plastic consists essentially of gelatinised nitro-cellulose and camphor in proportions usually varying from 70 to 75 per cent of the former and 30 to 25 per cent of the latter. The proportion of nitro-cellulose in motion picture films ranges from 80 to 90 per cent. In addition to the essential constituents there are frequently coloring or mineral matters.

Its Properties.—The plastic possesses properties which render it suitable for a great variety of purposes. It is hard, tough, and elastic, and under the influence of heat it is capable of being moulded into shapes which it retains on cooling. It is unaffected by water. It can be prepared in thin transparent sheets, and by the addition of suitable coloring matters can be made of the most varied tints. It can also be used in solution with alcohol and ether as an adhesive lacquer or varnish, when a very durable protective coating is obtained.

Inflammability.—It possesses however the serious defect of being highly inflammable, will ignite very readily, and burns with great rapidity and fierceness. Moreover, in certain circumstances it may ignite without the direct application of flame. The ignition of a film in a motion picture machine is a familiar occurrence, and cases have been recorded of the ignition of articles in shop windows by the accidental focussing of the sun's rays upon them. As other examples of the effect of radiant heat, mention may be made of cases in which contact with electric light bulbs and steam radiators has caused ignition.

If submitted to a moderately elevated temperature for a considerable time it suddenly decomposes with the evolution of considerable heat and the emission of large volumes of carbon monoxide and nitric oxide, both of which are highly poisonous, and of gaseous decomposition products of camphor and a small proportion of other gases, including hydrocyanic acid (prussic acid). The fumes are very inflammable and, when mixed with a suitable quantity of air, are highly explosive. The quantity of hydrocyanic acid in the fumes is small, and cannot be regarded as a serious danger. With inferior plastics in certain circumstances this decomposition will take place at, or even below the temperature of boiling water (212° F.), and comparatively few grades can withstand a temperature of 300° F. At this temperature ordinary inflammable substances are generally unaffected. Although there is a considerable difference in the stability to heat in different makes or brands, in practice this is not sufficient to justify a distinction being drawn between them.

Dangerous Qualities.—One of the peculiar dangers of pyroxylin plastic is that, in itself, it contains sufficient oxygen to support its own combustion, and once ignited will continue to burn in the absence of air, although without flame. For this reason a fire cannot be extinguished by excluding air in the same manner as an ordinary fire. Chemical fire extinguishers, therefore, which depend on a blanketing by gas, are of little use; although they may extinguish the flame they will not stop the combustion. Having regard to the fact that two of the three conditions necessary for combustion are actually present, it follows that the only way to extinguish burning plastic is to eliminate the third essential condition by reducing the temperature below that at which combustion can be maintained. The simplest and only really practical means of doing this is by the application of water, and therefore all places in which pyroxylin plastic is handled or stored, a complete automatic sprinkler system is very necessary. It is true that, under certain conditions, it will burn under water for a short time, but the temperature is speedily reduced by the water below that which is necessary for the maintenance of combustion. If sand is used, although the flame may be temporarily extinguished, the plastic will continue decomposing and emitting gases which will ignite on contact with flame.

Extinction of Fire Difficult.—Should a substantial quantity get alight, the extinction of the fire may become a matter of extreme difficulty, and even sprinklers may fail to save the building. In tests made in New York, 50 pounds of pyroxylin plastic resulted in flames of intense heat 12 to 15 feet in extent. A fire in which a large quantity is involved is of a specially dangerous character owing to the density and poisonous nature of the fumes, which render it difficult for the firemen to approach the seat of the fire. The rapidity with which the fire spreads renders its isolation an exceptionally arduous task. When well alight, great jets of flame are shot out, and the risk to adjacent buildings, even if they are not actually adjoining, is thus greater than with an ordinary fire.

The opinion sometimes expressed that pyroxylin plastic is liable to spontaneous ignition at ordinary temperatures appear erroneous nor is it explosive in ordinary circumstance. There has been however, explosions of the gases evolved from decomposition, and, as is the case of many other substances, the dust is liable to cause explosion.

Safer Substitutes.—Various attempts have been made to neutralize the inflammability of this plastic, but so far as can be ascertained it has not been found possible to reduce the inflammability to any great extent without sacrificing some of the properties on which its commercial value depends. Greater success has attended the efforts to find a total substitute, several of which are on the market. The Underwriters' Laboratories have recently approved three makes of motion picture film, all of which are acetate cellulose compounds; these by test were shown to have a less fire hazard than paper or pasteboard of equal thickness.

The articles most likely to cause accident are those worn on the person, such as combs, hairpins, cuffs, and collars; and it would appear from the list of accidents of which there are records, that the majority of the serious accidents which have occurred have been due to the ignition of articles of this description. In general they should not be sold without some clear indication of their nature being given, by distinctly marking or labeling the articles with the words "danger, inflammable."

Storage.—Accidents in stores, both wholesale and retail, have been very rare, and the danger of a fire arising owing to the presence of such articles is remote, if ordinary precautions are observed. The bulk of the articles are necessarily kept in packages, and the main stock is kept in the drawers or shelves of the shop or in a stock room. However, any large storage of pyroxylin plastic is a very distinct hazard, because of the intense heat, rapid combustion and difficulty in extinguishing.

Danger in Factories.—In factories the greatest danger is due to the creation of waste and the large amount usually out on tables, etc., waiting to be worked on. Waste should not be allowed to accumulate on the floor, but should be collected from time to time (if possible as it is created) in suitable waste cans, kept partly filled with water. (For description, see page 224.) At the end of the day it should be removed from the workrooms and placed in metal boxes provided with lids and marked "Dangerous." It should not be stored in sacks. Owing to the fact that a commercial value now attaches to waste, greater care is taken for its safe preservation than was formerly the case.

Saws should run in water and all machines which produce a dust should be provided with suction collecting systems,—discharging into water.

The amount in the workrooms should be limited as far as possible, and should in no case exceed one day's requirements.

All stock, either raw or in process of manufacture, should be kept in small self-closing cans, preferably of a material rather low in conductivity, such as molded asbestos board, holding not over 25 pounds, and finished goods should be removed with all due diligence.

The great inflammability of pyroxylin plastic requires extra safeguards where it is present in considerable quantity. In the fires that have occurred where it is being worked, usually some one is seriously burned even if adequate exit facilities are provided. To prevent the spread of fire from one work bench or machine to another each should be set off by an incombustible screen or partition extending about 2 feet on all sides.

The work people should be instructed as to the steps to be taken in case of fire.

Smoking and Lights Dangerous.—Smoking and the introduction of matches into the workrooms should be prohibited.

Open lights and fires are a source of danger, and the requirement that all lighting be from incandescent electric lights should be strictly adhered to. It is inadvisable to allow plastic to remain in contact with sources of heat. The use of sealing wax and soldering should be avoided as far as possible; if such operations are necessary, they should be performed with all the precautions possible to prevent contact with heated tools or direct flame.

There should be adequate means of escape, not only from the room, but from each working place; gangways, passages and staircases should be of sufficient breadth and be kept free from obstruction; doors should open outwards.

Safeguards.—In general the storage and handling should be in one story buildings, and extensive storage should be prohibited inside a building. Where possible only small vaults or special buildings should be used for storage and these should be well away from other buildings or adjacent to blank walls. Substantial roof houses are well adapted for storage, as eliminating the exposure hazard.

Very extensive vent openings are necessary to prevent excessive pressure inside the place of storage in case pyroxylin plastic is ignited or decomposes, and such vents must be so arranged as not to expose other property.

In general storage should follow the regulations covering *Nitro-Cellulose Motion Picture Films* issued by the National Board of Fire Underwriters, which are as follows:

STORAGE OF PYROXYLIN PLASTIC OR NITRO-CELLULOSE PICTURE FILMS*

Nitro-cellulose motion picture films should preferably be stored in a separate building or vault, not exposing other property or occupancy; if a limited quantity is permitted in a building with other occupancy, or in an exposed building, it must be in standard fireproof vaults, safes or cabinets.

1. FILM REELS.—Each reel of film shall be kept in a separate metal box with tight-fitting cover, except when in use.

NOTE.—A reel ordinarily contains 1,000 feet of film 1 11/32 inches wide, and weighs about 5 pounds; diameter of reel is approximately 10 inches.

2. VAULTS.—Where the maximum degree of protection for valuable films is the primary consideration, vaults shall be constructed according to requirements for Class "A" vaults. This type of vault involves massive construction designed to resist long continued fire, impact of falling bodies, and attack by burglars (in so far as this feature can properly be incorporated in these specifications).

Where the primary consideration is to minimize the fire hazard in a building incident to the films therein, vaults shall be constructed in accordance with the requirements for Class "A," "B" or "C" vaults.

See specifications for vaults, page 458.

No one vault or compartment shall exceed in size 750 cubic feet.

To prevent abnormally high temperature within the vault, glass windows and skylights should be avoided; likewise proximity to boiler stacks and similar sources of heat.

Automatic sprinklers should be installed inside each vault.

Vaults not exceeding the size and capacity specified below for safes and cabinets will be considered satisfactory if of equivalent strength and insulation to that required for safes and cabinets.

Editor's Note.—In a test made of a vault holding approximately a ton of film, a temperature over 1000° F. was obtained. Although nearly all the films were in the usual metal containers, the entire contents of the vault burned in less than 3 minutes. Flames extended through the vent opening provided for a distance of about 75 feet. From this and from actual fires it is evident that such fires are of great fierceness and require a good class of construction. The time interval before the contents are destroyed is so short that except for perfect tightness, to prevent the escape of gas, there is little need for especially strong or thick vaults. The low point of decomposition, about 300° F., requires a good form of container to prevent ignition from an outside fire, especially if settlement of the floors or a stream of water playing on the vault may result in cracked walls. Because of these conditions, it is evident that a lighter form of vault would be satisfactory where the vault was not exposed; for yard vaults or vaults on roofs of fireproof buildings, the latter of which should be a very acceptable location in city plants, there does not appear to be any reason why a 6-inch tile or 4-inch concrete wall is not satisfactory.

3. SAFES.—Size not to exceed 150 cubic feet. Safes shall have an angle iron frame at least ¼ x ¼ x 2 inches and continuous at all edges. On safes larger than 40 inches high, 30 inches wide, and 30 inches deep, an additional stiffening of heavy steel at least ¼-inch thick, and of width proportioned to size, but never less than 2 inches, shall be used at top, bottom and sides. Sheet steel plates shall be not less than No. 12 U. S. gauge

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* As adopted by the National Board of Fire Underwriters.

for the outer shell and not less than No. 14 for the inner shell. Filling to be of cement concrete or its equivalent not less than 5½ inches thick, except that the doors may have at least 4 inches of concrete with a sealed air space for the lock and bolts. Door shall have stepped sides so as to be smokeproof. No cast iron to be used in the construction of the safe, except such parts as casters, hinges and flanged door frames. Other containers of no more than 150 cubic feet capacity and approved as the equivalent of above described safes may be accepted in lieu thereof.

4. CABINETS.—Two hundred reels of film weighing not more than one thousand pounds in the aggregate may be stored in cabinets, but no one cabinet shall contain more than 50 reels (250 pounds). When two or more cabinets are used they shall be in a separate room with outside ventilation and enclosed by fireproof partitions with fire doors of the vertical shaft type at communications. There shall be at least 10 feet clear space between cabinets unless an incombustible shield is provided at each side of each cabinet extending 2 feet beyond cabinet in all directions, in which case the distance between cabinets may be only 4 feet.

Cabinets shall be tightly enclosed and may be made of suitably stiffened sheet iron at least No. 18 U. S. gauge in thickness, double walled with 1½ inch of air space; doors shall be constructed equivalent to walls of the cabinet, shall be self-closing, fit closely and be kept locked.

Other containers having a capacity not exceeding 50 reels of film each and approved as the equivalent of the cabinets may be accepted in lieu thereof.

5. PRESSURE RELIEF FOR VAULTS, SAFES AND CABINETS.—Each container for film storage shall be provided with a pressure relief vent opening to the outside of the building, directly through an exterior wall, or through a separate stack with walls of reinforced concrete or brick at least 5 inches thick and shielded at top. The effective sectional area of the opening shall be at least 70 square inches for each 100 reels (500 pounds) of film capacity. The capacity of vaults shall be rated at three reels per foot of cubical contents; the capacity of safes and cabinets, or small vaults without aisle space, shall be rated at six reels per foot of cubical contents. Reels shall not be placed near enough to vent opening to reduce its effective area. A permanent guard shall be installed to prevent films from being forced against the vent openings of small containers. In fireproof buildings horizontal ducts may be permitted to connect the relief openings in vault separately to the outside of the building, provided the walls are made of solid masonry at least 5 inches thick and securely supported. A riveted sheet metal pipe of at least No. 18 U. S. gage in thickness may be permitted to separately connect the vent opening of each cabinet to the outside of the building, provided the pipe is covered with at least 1 inch of approved heat insulating material. Such pipes shall not be nearer than 9 inches to combustible material.

Each pressure relief vent shall be protected against the weather by thin glass (1/16-inch thick) painted a dark color or by other incombustible fragile material in a sash arranged to open automatically in case of fire by the use of a fusible link or thermostat placed inside the film container. The effective sectional area of the vent opening shall correspond with the actual area of the glass. No pane of glass to be smaller than 200 square inches. Muntins to be constructed as lightly as possible so as to break readily.

A light wire screen, not coarser than ⅛-inch mesh, shall also be placed over each vent at a point between the glass sash and the container, so arranged as not to interfere with the automatic operation of the sash.

The outlet of each vent shall be located at a point above the roof. Exception will be made only where a different location of the outlet will not expose other property in the same or adjacent buildings, and then only by special permission of the inspection department having jurisdiction.

6. VENTILATION OF VAULTS.—There should be no ventilation of vaults other than a pressure relief opening, discharging directly to the outside of the building. Blower systems circulating air in the vault are objectionable, even after every reasonable safeguard has been provided.

Artificial ventilation of vaults is sometimes desired in factories handling new material as in motion picture film printing establishments. In such cases the additional fire hazard in connection with the ventilation may be somewhat reduced if the intake and discharge openings in the vault connect directly to the outside of the building through wall or a flue with masonry walls at least 4 inches thick. The outlet and intake openings shall not expose or be exposed by other property. Only suction blowers drawing air away from vault shall be used.

HANDLING OF PYROXYLIN PLASTIC OR NITRO-CELLULOSE MOTION PICTURE FILMS*

1. PRINTING, DEVELOPING, EXAMINING, REPAIRING AND EXCHANGE ROOMS.—(a) Shall have outside ventilation and be separated from each other and the balance of the building by tight partitions of fire-resistive material, with fire doors of the corridor type at communications, partitions and transoms. Doors should contain no glass other than wired glass.

(b) Such rooms to be used neither for storage nor handling of combustible materials, other than the films. The furnishings should be of fire-resistive material.

(c) The number of reels of films not in special rooms exposed in a single room at any one time shall be limited to 20.

2. SCRAP AND WASTE.—All scrap or waste shall be kept under water, in self-closing standard metal waste cans or their equivalent, and removed from the building at least once each day to a safe location; such waste to be kept separate from paper waste or other rubbish.

3. CEMENT.—Any compound of collodion and amyl acetate or similarly inflammable cements inside the building shall be limited to one gallon, not exceeding the quantity required each day.

4. MOTION PICTURE MACHINES AND BOOTHS.—Shall be safeguarded in accordance with the requirements of the National Electrical Code. The booth may be omitted if the machines are in a separate room enclosed by incombustible partitions with fire doors of the corridor type at communications.

5. POWER.—Electric motors, if used, should preferably be of the induction type without commutators, or if of the Direct Current type to have enclosed commutators. All switches, rheostats, or other current-controlling devices must be enclosed in approved dust-proof and fireproof cabinets.

6. LIGHTING.—Shall be by incandescent electric lights only; lamps, if subject to mechanical injury, to be protected by approved wire guards. Entire installation shall be in accordance with the requirements of the National Electrical Code.

7. HEATING.—Only hot air, hot water or steam heat shall be used. The heating pipes should be preferably overhead attached to the ceiling. Steam and hot water pipes or radiators, if on side walls, shall be safeguarded by the use of sheet metal or heavy galvanized wire netting with not over ¼-inch mesh held firmly in place at least one inch from pipes; or by covering space between back of benches and walls with heavy galvanized

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* As adopted by the National Board of Fire Underwriters.

wire netting, with not over ¼-inch mesh, securely stapled to bench and wall, but sloping so that it may not be used as a shelf. No hot air nor other floor registers shall be used, nor shall any register be less than 6 inches above the floor.

8. SMOKING AND CARRYING OF MATCHES.—Shall be strictly prohibited.

9. PROTECTION.—All buildings in which there is a total of more than 50 reels of films (250 pounds), shall be equipped with an approved system of automatic sprinklers. Each room shall be equipped with at least one approved hand fire extinguisher. At least one pail of water and one pail of sand shall be provided for each vault, safe or cabinet in use.

MOTION PICTURE MACHINES AND THEATRES

To regulate the installation, operation and maintenance of motion picture machines and to regulate the construction and arrangement of picture machine booths and of audience rooms in which motion picture exhibitions are to be given, the National Board of Fire Underwriters issued a suggested ordinance; except for the sections covering permits and enforcement, this ordinance is given below:

MATERIALS.—Motion picture machines must be installed in an enclosure constructed entirely of fire-resistive material, which may include only brick, tile, concrete, galvanized iron, hard asbestos board, asbestos building lumber, two inches of solid metal lath and Portland cement plaster, or their equivalent.

LOCATION.—The booth must not be placed directly over an exit, and in all cases must be securely anchored or fastened to prevent dislodgment in case of panic. A separation of at least twelve inches must be maintained between the top or sides of metal booths and any inflammable material. The enclosure must be not less than seven (7) feet in height, with area of floor space varying in accordance with the number of machines or devices installed in such booths, as follows:

1 Picture machine	6 feet x 8 feet
1 Picture machine and 1 stereopticon	9 feet x 8 feet
2 Picture machines and 1 stereopticon	12 feet x 8 feet

BRICK, TILE OR CONCRETE BOOTHS.—Walls, roof and floor of brick or tile shall be at least 8 inches thick; if of reinforced concrete, they may be only 4 inches thick.

METAL OR ASBESTOS BOOTHS.—Frame to be made of at least 1½-inch by 1½-inch by ¼-inch angle or tee irons, as follows:

Four outside horizontal members at top and bottom.

Four corner uprights.

Intermediate uprights on sides and intermediate members on roofs, spaced at least every two feet.

Doorway to be two feet wide by at least five feet high, with an angle iron framing.

All joints in frame to be made with 3/16-inch steel plates, to which each angle iron or tee iron shall be riveted or bolted by the use of at least two ¼-inch bolts or rivets. All bolts or rivets to have flat heads, said heads always to be placed on exterior side of booth and properly countersunk.

COVERING OF BOOTH.—Sides and top of booth and main or entrance door shall be covered with hard asbestos boards or asbestos building lumber, of at least ¼-inch thickness, or their equivalent, or with steel or galvanized sheet iron of not less than No. 20 U. S. gauge. The asbestos, or its equivalent, shall be so cut and arranged that vertical joints between boards shall always come over an angle or tee iron, to which it shall be securely fastened by means of proper bolts and nuts, spaced not more than six inches apart. The sheet metal shall be so cut and arranged that joints shall always come over a member, be overlapped and bolted or riveted to such member; bolts or rivets to be spaced not over three inches on centers.

FLOORING.—Floor shall be made of two parts, an upper and a lower floor. Lower floor may be made of wood, 7/8-inch minimum thickness, supported on lower leg of horizontal angle irons. Resting on this floor shall be a floor made of hard asbestos board, asbestos building lumber of 3/8-inch minimum thickness, or an equally good non-combustible material.

OPENINGS.—There shall be not more than two openings in the booth for each machine—one for observation by the operator and one for operation of the machine. Opening for machine shall be not more than seventy-two square inches. Opening for operator shall be not more than four inches wide or more than twelve inches high. The two openings for each machine shall be provided with gravity doors, constructed of metal not less than 3/16-inch in thickness; when closed they shall overlap the openings at least two inches on all sides, and be arranged to slide, without binding, in properly constructed grooves; said doors to be held open normally by use of a fine combustible cord fastened to a fusible link which melts at a temperature of 160 degrees F., the whole so arranged that the door may be easily released and closed by hand.

The main or entrance door shall be hung on at least three heavy hinges and arranged to close against a substantial metal rabbet. The door shall also be provided with a substantial spring which will keep it closed tightly.

SHELVES.—All shelves, furniture and fixtures within the booth shall be constructed of incombustible material.

VENTILATION.—Booths shall be provided with a ventilating inlet in each of three sides; to be fifteen inches long and three inches high, the lower side to be not more than three inches above floor level. Inlets shall be covered on the outside by a wire netting of not greater than 1/8-inch mesh, firmly secured by means of iron strips and screws or rivets, and on inside by gravity doors arranged to slide in properly constructed grooves, and which, when closed, shall overlap ventilator openings at least two inches on all sides; doors to be held open normally by use of a fine combustible cord fastened to a fusible link which melts at a temperature of 160 degrees F., so arranged that the doors may be easily released and closed by hand.

Near the center of the top of the booth shall be a circular opening of not less than ten inches in diameter, the upper side provided with an iron flange, securely fastened to the roof. Securely fastened to this flange shall be a metallic vent pipe of not less than ten inches in diameter, leading to the outside of the building or to a special incombustible vent flue; all parts of vent pipe to be at least six inches from any combustible material.

For the comfort of the operator it is important to provide for a constant current of air to pass outward through the opening or vent flue at the rate of not less than thirty cubic feet per minute when the booth is in use.

PORTABLE BOOTHS.—Portable booths shall not be used where a permanent booth has been or is installed, but only for the temporary one-night exhibition of motion pictures in places of assemblage, such as halls belonging to commercial organizations, churches, schools, etc., where it is deemed impracticable to install permanent booths made in accordance with the above specifications.

In constructing a portable booth the specifications for a permanent booth shall be followed, with the exceptions given below:

1. Intermediate uprights may be spaced every four feet.

2. Special means for ventilation need not be provided except that there shall be an opening for ventilation in the top of the booth, this opening to be ten inches in diameter and a metal sleeve at least eighteen inches in height, provided with a ventilating cap, shall be attached thereto.

3. The booth may be made in a folding type so constructed that when assembled it will be rigid and all joints tight so that flames may not pass through them.

4. The base of booth shall have a flange extension outward on all four sides provided with a sufficient number of holes, through which booth may be fastened to floor.

GENERAL PROVISIONS.—The motion picture machines must be securely fastened to the floor to prevent accidental overturning or moving of same.

Shall be equipped with a feed reel enclosed in a metal magazine constructed of 20 U. S. gauge metal, with a slot at the bottom only large enough for film to pass out, and with cover so arranged that this slot can be instantly closed. No solder to be used in the construction of this box. Door on side shall be of metal and provided with spring hinges and latch, which will keep door closed tightly.

Shall be provided also with a take-up reel in a magazine, similar to that used to enclose feed reel. A slot to be provided only large enough to receive the film, and a door at the side to be provided to remove film. The door must be of metal and equipped with spring hinges and latch to keep same securely closed.

A shutter must be placed in front of the condenser, so arranged as to be automatically closed when film is stationary.

Resistance box must be kept not less than one (1) foot from any combustible material, or must be separated from it by a slab of slate or marble. The resistance box must be surrounded with a substantially attached metal guard having a mesh not larger than one-half inch, which guard is to be kept at least one inch from outside frame of rheostat.

The lamp must not be mounted upon a base or frame composed of wood.

LIGHTS.—No artificial light shall be used except that produced by electricity. All electric wiring to and in the booth, except necessary flexible conductors, shall be installed in metal conduit. One light will be allowed for each machine and one for the rewinding bench, but all such lights shall be provided with wire guards, and reinforced cord shall be used for pendant purposes. If house lights are controlled from within the booth, an additional emergency control must be provided near the main exit and kept at all times in good condition.

FILMS.—No films shall be exposed in the booth at the same time other than the one film in process of transfer to or from the machine or from the upper to lower magazine, or in process of rewinding. A separate case, made without solder, shall be provided for each film when the same is not in the magazine or in process of rewinding, said films to be kept in these cases. No material of a combustible nature shall be stored within any booth except the films needed for one day's operation.

EXTINGUISHERS.—At least two standard hand chemical fire extinguishers shall be provided, one inside the booth and located in an accessible place within easy reach of the operator, the other located outside of the booth near the door to same.

SMOKING, ETC.—Neither smoking nor the keeping nor use of matches shall be permitted in any booth, room, compartment or enclosure where a motion picture machine is installed.

NOTE.—It is suggested that at some convenient time during each exhibition a bulletin stating the precautions taken to reduce the danger from fire and a caution against the dangers of panic, be thrown upon the screen.

ENVIRONMENT, ETC.—No motion picture machine shall be installed, maintained or operated in any building that does not abut directly upon a street; nor shall any such machine be installed, maintained or operated in connection with any exhibition room contained in a building occupied as a hotel, tenement house, or lodging house; nor in factories or workshops, except where the exhibition room and motion picture machine are separated from the rest of the building by unpierced fireproof walls and floors; and in no case shall the main floor of such exhibition room be more than four feet above or below the adjoining grade level. To overcome any difference of level on the ground floor gradients shall be employed of not over one foot in ten feet; no steps shall be permitted. Exit doors must be at the same level as the sidewalk.

If the walls of the auditorium contain wood studs, they shall be covered with either expanded metal lath or wire mesh and plastered with three coats of plaster, or be covered with one-half inch plaster boards and plastered or covered with metal. The joints shall be properly filled with mortar. The ceilings of all such rooms shall be plastered with three coats of plaster on wire mesh or metal lath, or covered with one-half inch plaster boards and plastered or covered with metal. If there be a basement or cellar, the ceiling under the auditorium floor must be plastered with three coats of plaster on wire mesh or expanded metal lath, or be covered with one-half inch plaster boards and plastered or covered with metal.

Any motion picture exhibition room accommodating more than three hundred people, or containing a gallery or galleries, shall be built in compliance with the requirements for theaters and opera houses. (See the Building Code issued by the National Board of Fire Underwriters.)

EXITS.—All motion picture exhibition rooms shall be provided with at least two separate exits, one of which shall be in the front and the other in the rear, both leading to unobstructed outlets on the street. The aggregate width in feet of such exits shall be not less than one-twentieth of the number of persons to be accommodated thereby. No exits shall be less than five feet in width, and there shall be a main exit not less than ten feet in total width.

If an unobstructed exit to a street cannot be provided at the rear of such buildings, as herein specified, either an open court or a fireproof passage or corridor must be provided from rear exit to the street front, of at least four feet in width for exhibition rooms accommodating 50 persons or less, and six inches additional for each additional 50 persons accommodated by such room. Such passage must be constructed of fireproof material and must be at least ten feet high in the clear. The walls forming such passage must be at least eight inches thick, of brick or other approved fireproof material, and if there be a basement the wall on the auditorium side should either run one foot below the cellar bottom or may be carried in the cellar on iron columns and girders properly fireproofed. The ceiling of said passages, and, if there be a basement, the floor, must be of fireproof construction.

If unobstructed rear exit or exits to a street are provided, the said exit or exits must be of the same total width required for the court or passage above mentioned. Said passages and exits to the street, as above, must be used for no other purposes except for exit and entrance, and must be kept free and clear.

The level of the open court or passage at the front of building shall not be greater than one step above the level of the sidewalk, and the grade shall not be more than one foot in ten, with no perpendicular rises.

SEATS AND AISLES.—All seats in any exhibition room for moving picture machines shall be not less than 32 inches from back to back and securely fastened to the floor; they shall be so arranged that there will be not more than ten seats in a line between aisles, nor more than four between any seat and an aisle. All aisles shall lead directly to exits and all exits shall be directly accessible to aisles. No aisles shall be less than three feet in width where they begin, and shall be increased in width toward the exits three inches to every ten running feet length. All exit doors shall be arranged to swing outward and be provided with fastenings such as can be opened readily from the inside, without the use of keys or any special effort, but not locked when the room is open to the public.

All the requirements of this section relating to seats, aisles, passageways, exits and doors shall apply in connection with each open-air motion picture exhibition.

DOORWAYS.—Every exit doorway leading from the exhibition room shall have over the same on the auditorium side, the word "EXIT" in letters not less than six inches high, or an illuminated sign with letters of the same height. Where illuminated signs are not provided there shall be at least one red light over each exit doorway. The exit doorways shall be numbered with figures not less than six inches high. Light used in marking exits or lighting passageways, stairways or inclines leading from them shall not depend upon or be controlled by wires, switches or fuses located in room, compartment, booth or enclosure containing motion picture machines, but shall be controlled from the ticket office.

STORAGE AND HANDLING OF INFLAMMABLE LIQUIDS

Hazards.—The hazard from inflammable liquids is two-fold—the danger of an explosion or fire from the gases liberated, and the spread of fire in and from the liquid.

As inflammable liquids are nearly always of considerable monetary value, the usual containers in which they are handled in bulk are tight, with small chances of leaking. The Interstate Commerce Commission and the Department of Commerce have issued requirements covering the construction of shipping containers and it is safe to say that any inflammable liquid in an original shipping container, providing it is in good condition, can be stored in practically any place with slight danger of fire or explosion resulting from it. But with these containers open very distinct hazards arise, first, that of the liberation of dangerous gases and, second, that of spilling or igniting the liquid contents.

Properties of Liquids.—The Underwriter's Laboratories, in classifying the hazardous properties of liquids, consider eleven properties, as follows:

1. Explosive characteristic.
2. Combustibility; as indicated by the flashing point.
3. Volatility; as indicated by the
    - (a) Vapor pressure at 68° F.
    - (b) Boiling point at standard pressure.
4. Violence of vapor air explosions.
5. Vapor density.
6. Ignition point.
7. Resistance when burning to the extinguishing action of water.
8. Chemical activity. Hazards in combination.
9. Ability as a corrosive agent.
10. Ability towards leakage.
11. Ability as a factor in spontaneous ignition.

Characteristics 1, 3, 4 and 5 are rated with reference to the flashing point. The flashing point is in this way made a determinative factor in rating the hazard and is not, therefore, considered separately.

Under this classification:

Ether rates	100
Gasolene	90–100
Turpentine	40–50
Kerosene (F. P. 38° C. 100° F.)	30–40
Paraffin Oil (F. P. 229° C. 444° F.)	10–20

Flash Point.—Although the above classification is best to determine the exact relative hazard of liquids, for general purposes a simpler method is necessary; any of the liquids if heated and ignited will burn intensely, with little difference between them. The main hazard then to differentiate upon is the volatility and combustibility, which can best be determined by the flash point. This has been taken as the deciding factor in a recommended ordinance issued by the National Board of Fire Underwriters and abstracted below; the requirements given in this ordinance are also essentially those recommended for adoption by the insurance associations for their guidance in accepting risks.

Cleaning Substitutes.—As a substitute for benzine, gasoline, naphtha, ether, carbon bisulphide and other dangerous substances used for cleaning and extracting, the Underwriters' Laboratories have listed Carbona as non-combustible and non-flammable, Detergene as in the same class as turpentine, Carbozine, Claroline and Woolleys' Solvent as in the same class as kerosene, and trichlorethylene and tetrachlorethane as not forming inflammable or explosive mixtures with air under ordinary conditions, but at high temperatures giving off vapors that are moderately combustible. The last two and chloroform, which is also a safe liquid for such purposes, possess toxical properties which make ventilation a requirement for their use.

Carbon tetrachloride is also of value for cleaning purposes; it has high extinguishing value and is used to a large extent in small fire extinguishers. When mixed with gasoline, it reduces the flash point, until with a mixture of 40 to 50 per cent of tetrachloride, the hazard is removed.

Gasoline.—The more volatile parts of petroleum are known as naphtha by the refiners, but to the general public the term gasoline covers the general class used in every day life; gasoline is lighter than water and therefore can not be extinguished by the application of water, except as the cooling effect of the water diminishes the heat generated to such an extent as to bring the heat in the burning liquid below the flashing point. Fires are often spread by the application of water, the oil staying on top and continuing to burn.

Gasoline gives off vapor at practically all temperatures, the amount of vapor varying with the temperature; for this reason it is best to store in as cool a place as possible; underground storage is the only safe method. The vapor of gasoline when pure, not mixed with air, will not explode. It becomes violently explosive when mixed with air, when the proportion of vapor is from 3 per cent to 6 per cent, after which last figure it is no longer explosive.

The vapor is 2.77 times as heavy as air, therefore, it tends to settle to the ground and to collect in low spots unless a draft or ventilation disperses it. This feature is the most dangerous property of the vapor, and causes many serious fires, as the vapor will travel several hundred feet under the right circumstances, until reaching a flame it will ignite and flash back to the origin of the vapor, setting fire to any inflammable substance in its path. Many instances are on record of the vapor lying in a layer on a garage or dry-cleaning floor, or being in a pit or basement, and, when ignited by a dropped match, spark from electrical apparatus, or from friction, or back-fire of a gasoline engine, spreading so rapidly as to destroy the entire contents of the building in a very short period of time.

Gasoline Containers.—In handling gasoline, open receptacles should never be used, and discharge should be direct from one closed container to another, with as little chance of its getting in contact with the air as possible. All containers which are partly filled with gasoline or have held gasoline, contain the vapor in a more or less mixture of air. On filling, this is driven off and immediately mingles with the lower stratum of the air; if no means of its flowing away are provided, i. e., proper ventilation is not established, it forms either an explosive or a burnable mixture, which only needs a spark or flame to set it off.

The principal danger is in the handling of gasoline, as with underground storage the hazard of storage is well safeguarded; laws should be stringent as to its use and should be strictly enforced by the fire department.

Fire Risks.—In respect of fire risk, the crude petroleums are less uniform in character than the fats and oils, the risks of which are confined within narrow limits, while those of petroleum have a wide range. Many of them contain gases that are liberated at the ordinary temperature, and, when condensed to the liquid condition, boil a little above the freezing point of water. Such gases do not occur in fats or oils. Other constituents of crude petroleum are extremely volatile and inflammable, the vapors forming explosive mixtures with air. Finally, other constituents are solid, are not easily ignited, and do not explode until high temperatures are attained.

The low-boiling and highly volatile constituents of petroleum and mineral oils belong to the most dangerous of substances so far as risk of fire and explosion are concerned. However, as the boiling point rises and the volatility diminishes, the danger also lessens, until we arrive at the paraffins, which are about on a par with the fats and oils.

Alcohol.—Alcohol is a generic term, and applies to a large series of organic compounds consisting of carbon, hydrogen, and oxygen, and having the same fundamental chemical composition. The chief member of the series is spirits of wine, which is called alcohol when chemically pure and of a certain degree of strength.

The alcohols are for the most part liquid and volatile, only a few—e. g. mannite and erythrite—being solid and non-volatile.

They are generally combustible, some of them readily inflammable; and though perfectly safe alcohols are not unknown, the name "alcohol" is associated with the idea of inflammability and fire risk, and to a certain extent also with that of explosion (especially when warmed alcoholic vapors are in question). For this reason very stringent precautions should be prescribed for all premises where alcohol is employed.

Alcohols of different strengths gives off inflammable vapor at the following temperatures:

Absolute alcohol	at	51°	F.	40 per cent alcohol	at	78¾°	F.
80 per cent	"	68°	"	30 per cent	"	85°	"
70 per cent	"	69¾°	"	20 per cent	"	97¼°	"
60 per cent	"	71½°	"	10 per cent	"	120¼°	"
50 per cent	"	75¼°	"	5 per cent	"	143½°	"

The final limit of inflammability is only attained between 5 and 3 per cent.

Strong alcohol will ignite readily even in the cold; but for that of 60 per cent strength a temperature of 80½° F. is necessary, and 87¾° F. for 45 per cent spirit.

Alcohol of 99-99½ per cent strength is classed as alcohol, that of 95-97 per cent as fine spirit, that of 80-86 per cent as raw spirit, and that of 80 per cent strength as burning spirit.

Alcohol between 60 and 99½ per cent strength is more inflammable than ordinary petroleum (f. p. 70° F.); but, on the other hand, the vapors are far less explosive, since to attain this condition they require to be strongly heated and placed in contact with a flame or electric spark. In point of general fire-risk, alcohol is far below ether, benzol, carbon disulphide, and similar liquids.

Special danger attaches to alcohol by reason of its high diffusibility. With the exception of glass and metals there are few substances through which alcohol is unable to penetrate, even when of only 60 per cent strength. Neither wooden vessels nor the most compact cement tanks, etc., can prevent escape, and the stronger the alcohol the quicker the dispersion.

Denatured Alcohol.—To cheapen alcohol for technical purposes, it is denatured, generally with methyl alcohol (2 per cent), which, however, increases the risk of fire and explosion, owing to the rapidity with which the adjunct evaporates, and to the explosive vapors it yields.

Use No Rubber.—Rubber pipes or tubing made of organic materials should never be used for conveying alcohol, or connecting vessels containing that liquid, when the strength of the spirit is above 50 per cent. Flexible metallic tubing, which is now made of good quality, is necessary in such cases.

Spirituous Liquors.—Among spirituous liquors, only such as are rich in alcohol are dangerous, and even then the risk is not high, since it is only when they are in a warm and undiluted condition that they readily ignite. Inflammable vapors are liberated by: Ordinary brandy, at 84° F.; Dutch gin at 89½° F.; whisky at 82½° F.; rum, arrack, and cognac at about 77° F., according to strength; and by sherry and port wines at 129° F.

Ethers.—Like "alcohol," the term "ether" is a generic appellation for a large series of organic compounds of definite composition. The chief representative of the group is sulphuric ether, commonly known as ether.

The ethers are usually volatile, readily inflammable and combustible, far more so indeed than the alcohols, from which latter they differ in the explosive character of their vapors at low temperatures, alcohol vapors being explosive only when hot.

The ethers usually have lower boiling points than alcohols, there being but few exceptions to this rule.

Wherever large quantities of ether vapor are liberated, great danger of explosion is imminent.

Carbon Disulphide.—Carbon disulphide, on account of its great volatility, must always be kept under water, by which it is dissolved to the extent of about 0.5 per cent without any dangerous properties being thereby imparted to the water itself. Owing to the great density and high explosive factor of the vapors, the floorings of all rooms where it is employed must be well made, to prevent penetration by the vapor; and all depressions to which the vapor could gain access must be well covered. Where large quantities of carbon disulphide are employed, no fires should be allowed within 50 ft. of the workrooms.

Despite their volatility the vapors of carbon disulphide are tenaciously retained by porous, fibrous, woollen materials; and in the ground they are retained for more than a year. By reason of this retentive faculty, carbon disulphide cannot be used for extracting fat from wool, though otherwise the best agent for that purpose. All porous materials treated with carbon disulphide remains dangerous for a considerable time from the above cause.

In itself, liquid carbon disulphide is not explosive, but the presence of even 6 per cent of its vapor in air is sufficient to impart an explosive tendency to the latter. This tendency is retained in all cases where the proportion is higher; and therein lies the great danger of this substance. The risk is increased when the air is replaced by oxygen, violent explosions occurring whatever the proportions of the mixture.

Ethereal Oils.—The ethereal oils are of an oily nature, form grease spots (which, however, disappear on heating), are lighter than water, in which they are insoluble, and are soluble in the same solvents as fats.

The following typical ethereal oils may be cited:

Lemon oil, turpentine oil, lavender oil, wormwood oil (vermouth), pine oil, bergamot oil, nutmeg oil, mace oil, eucalyptus oil, juniper oil, and solid camphor. When treated with iodine, these oils detonate with liberation of vapors and great heat.

Aniseed oil, fennel oil, camomile oil, rosemary oil, carraway oil, thyme oil, sage oil, and hop oil. These detonate only slightly with iodine.

Rose oil, bitter almond oil, clove oil, mustard oil, valerian oil, and amber oil. When mixed with iodine they generate only a moderate amount of heat.

When old, resinfied, or rancid, the oils of the last two groups behave with iodine in the same manner as those of the first.

All the ethereal oils boil at temperatures above 284° F., and decompose at 390°-535° F. They will burn even without a wick, are more easily ignited than fats or oils, and are in general more dangerous than these latter. Exposed to the air, they take up oxygen and then form characteristic carriers of ozone.

A few of the ethereal oils (oil of turpentine) take fire on contact with fuming nitric acid or nitrating liquid.

Varnishes.—Varnishes may be divided into the following classes:

1. Oil varnish, usually boiled linseed oil, more rarely poppy or nut oil.

2. Lacquer varnish (true lacquer, also called spirit varnish). This class consists of resins dissolved in alcohol, wood spirit, acetone, benzol, or petroleum ether; or collodion wool dissolved in amyl acetate.

3. Oil lacquer varnish: solutions of resins in linseed oil oftentimes thinned with oil of turpentine or benzol; hence a mixture of 1 and 2.

4. Turpentine lacquer varnish: solutions of resins in oil of turpentine.

5. Resin oil lacquer varnish: solutions of resins in resin oils.

There are also sundry special lacquers, such as dull lacquer (sandarach in ether, benzol, or toluol), zapon lacquer (collodion wool or celluloid in amyl acetate), asphaltum lacquer (asphaltum in oil of turpentine). The resins most in use for lacquers and oil varnishes are, copal, dammar, anine, sandarach, mastic, shellac, pine resin, colophony, amber, and asphaltum.

The dangers of varnishes and lacquers increase in proportion to the dangerous character of the solvents used, the benzol and ether varnishes being the worst in this respect. Of late the extremely dangerous nitrous ether (b. p. 62° F.) has been largely used, but should not be employed except when greatly diluted with alcohol.

Lacquering Stoves.—An important and dangerous appliance in connection with the use of dip tanks and oil varnish is the dry-room or oven and the lacquering stove, in which the articles are dried and finished. The temperature in these stoves ranges from 120° to 160° F., and since the formation of explosive mixtures of vapor may occur, they must be fitted with proper ventilating outlets discharging into flues out of all communication with fire. Efficient ventilation must be provided in the room where the stove is located; naked lights must be prohibited, and the stove must be kept in good condition and free from leaks through which any inflammable vapors could escape. They are sometimes heated with hot air of high tension; explosions may readily happen, and therefore all fire or sparks should be rigidly excluded. The danger may be diminished by the introduction of carbon dioxide, 10 per cent being sufficient, though even in this event no guarantee of safety is possible.

Storage of Inflammable Liquids.—From the insurance viewpoint, the storing and handling of hazardous liquids are divided as follows:

Class A—Underground Storage without Inside Discharge

These storage systems, which are generally known as "Isolated Storage Systems," consist of an outside underground storage tank provided with suitable means for filling and for withdrawing the liquid it is designed to contain.

Systems which provide for storing and handling hazardous liquids outside of and so removed from adjoining property as not to create an exposure thereto, are considered the least dangerous.

Class B—Underground Storage with Inside Discharge

An inside discharge or so-called "long distance" system consists of an underground storage tank connected by piping to a pump or other means of transferring liquid into a building. This type of installation is regarded as more dangerous than systems not introducing hazardous liquids inside buildings. Where used its hazards should be recognized.

Class C—Portable Tanks

A portable tank consists of a metal receptacle mounted on wheels and provided with means for filling and withdrawing liquid.

These devices handle a considerable quantity of hazardous liquids inside buildings. Their use obviates the necessity for handling these liquids in buckets or other open receptacles. If used, their hazards should be recognized.

Class D—Stationary Tanks in Buildings

Tanks used for the storage and handling of various paint oils, linseed oil, varnishes, lubricating oils, kerosene, etc., and not for the storage of gasoline, benzine, alcohol, naphtha or liquids involving similar hazards.

These devices are not intended as substitutes for Class "A" or Class "B" systems when same can be installed, but are largely used to reduce the hazard of storing and handling of the first-above-mentioned materials in barrels, etc.

Class E—Outside Aboveground Storage

These storage systems, in the largest sizes, are such as are generally found in oil fields, oil refineries or distributing stations and consist of tanks located above ground.

The hazards of such systems depend upon the distance from burnable property and topography of the surrounding land, but owing to the tanks being above ground they are considered as more hazardous than underground systems of storage.

The National Board of Fire Underwriters have issued regulations under the title of *Containers for Hazardous Liquids,* covering the above classes. These in all essentials are the same as given in a model ordinance on this subject also issued by the board; this ordinance is given complete below.

USE, HANDLING AND STORAGE OF INFLAMMABLE LIQUIDS AND THE PRODUCTS THEREOF*

Section 2. Inflammable liquids are divided into three classes, according to the flash point, as follows:

Class I. Liquids with flash point below 27 degrees Fahrenheit (—3 degrees Centigrade) closed cup tester. (Equivalent to 30 degrees Fahrenheit open cup tester.)

Class II. Liquids with flash point above that for Class I and below 74 degrees Fahrenheit (23 degrees Centigrade) closed cup tester. (Equivalent to 80 degrees Fahrenheit open cup tester.)

Class III. Liquids with flash point above that for Class II and below 187 degrees Fahrenheit (86 degrees Centigrade) closed cup tester. (Equivalent to 200 degrees Fahrenheit open cup tester.)

The flash points shall be as determined with the Abel-Pensky or the Pensky-Martens closed cup tester. For commercial use, where the flash point is not within 9 degrees Fahrenheit (5 degrees Centigrade) the Tagliabue open cup tester may be used; provided that the flash point as given by the Abel-Pensky or Pensky-Martens testers shall be authoritative in all cases.†

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*Abstracted from a suggested ordinance recommended by the National Board of Fire Underwriters. Sections omitted covered matters of enforcement and permits.

† For description of testers and methods as used by the U. S. Bureau of Mines see technical paper No. 49 on "The flash point of oils—methods and apparatus for its determination."

This paper may be had upon request from the Director of the United States Bureau of Mines, Washington, D. C.

For ordinary usage, the comparison of open and closed cup testers may be assumed as follows:

$$\text{Degrees Fahr. (Tagliabue)} = 1^\circ + \frac{\text{Degrees Fahr.}}{0.94}\text{(Abel-Pensky).}$$

$$\text{Degrees Fahr. (Abel-Pensky)} = 0.94\ \text{Degrees Fahr. (Tagliabue)} - 1^\circ.$$

Representative examples of the classes of inflammable liquids are:

Class I

Ether
Carbon bisulphide
Gasoline
Naphtha
Benzole
Collodion
Hydrocarbon (gas drips)
Liquefied Petroleum gas

Class II

Acetone
Alcohol
Amyl acetate
Toluol

Class III

Kerosene
Amyl alcohol
Turpentine
Whiskey
Brandy

Section 24. Except in sealed containers, no Class I nor II liquids may be stored within 10 feet of any stairway, elevator or exit.

Section 25. In paint or oil stores, retail stores and jobbers' plants containing inflammable liquids, at least two exits shall be provided, one of which must be away from the point of storage.

Section 26. The mixing, storing or handling of inflammable liquids of Class I and II in open containers, is prohibited in any store in any building housing more than two families or in a frame building housing more than one family, provided that this shall not apply to drug stores where inflammable liquids are used in making and compounding medicines and prescriptions.

Section 27. The storage of inflammable liquids inside buildings, except in buildings now so used, shall be as given under the following sub-sections; provided that in a special storage room or fireproof building, conforming to requirements given in Section 29, an unlimited quantity may be maintained therein, except of Class I liquids:

a. Within the limits given in Section 45.

In frame buildings:

Classes I and II prohibited.

Class III. Maximum limit of any tank or container to be 60 gallons.

In other than frame buildings:

Class I, In sealed containers or safety cans of not more than 1 gallon capacity, and not exceeding a total of 10 gallons.

Class II, In sealed containers or safety cans of not more than 5 gallons capacity and in barrels, drums or tanks of not more than 60 gallons capacity. (Total quantity to be stored in this manner unlimited.)

Class III, In sealed containers of not more than 5 gallons capacity, in barrels and drums and in tanks not exceeding 120 gallons capacity. (Total quantity to be stored in this manner unlimited.)

b. Outside the limits given in Section 45.

In frame buildings:

Class I, In sealed containers or safety cans of not more than 1 gallon capacity, and not exceeding a total of 10 gallons.

Class II, In sealed containers of not more than 5 gallons capacity and in barrels, drums or tanks not exceeding 60 gallons capacity. (Total quantity to be stored in this manner unlimited.)

Class III, In sealed containers not exceeding 5 gallons capacity, in barrels and drums and in tanks not exceeding 120 gallons capacity. (Total quantity to be stored in this manner unlimited.)

In other than frame buildings:

Class I, Not exceeding 50 gallons in sealed containers or safety cans of not more than 1 gallon capacity.

Class II, In sealed containers or safety cans of not more than 5 gallons capacity, in drums and barrels and in tanks not exceeding 120 gallons capacity. (Total quantity to be stored in this manner unlimited.)

Class III, In sealed containers, drums and barrels and in tanks not exceeding 240 gallons capacity. (Total quantity to be stored in this manner unlimited.)

Section 29. Special rooms for storage of inflammable liquids and the handling and use of inflammable liquids shall, where called for in this ordinance, be constructed as follows: Walls, floors and ceiling to be of eight inches of brick or concrete, or four inches of reinforced concrete; door openings to other rooms or buildings to be provided with sills raised six inches and with automatically closing fire doors; windows to be wired glass in metallic sash and frames; no combustible material used in construction, except that floor surfacing may be of wood; proper ventilation provided; no opening to rooms below except as made necessary by trade or manufacturing process, and openings to rooms and other parts of building above to be provided with automatically closing fire doors or trap doors.

Section 30. Except where kept in sealed containers, Class I liquids shall be kept in storage tanks underground or outside the building and no discharge system shall have outlet inside building unless in a special room as given in Section 29. Provided that safety cans of not over ten gallons capacity may be used, except that if of over one gallon's capacity, they must be kept and used in special rooms as given in Section 29.

Section 31. No container containing Class II liquid and of over five gallons capacity may be used to fill other containers and appliances, unless kept outside the building or in a special room, as given in Section 29, and all drawing, except from safety cans, shall, where the nature of the liquid permits, be as provided for in Sections 66 and 67.

Section 32. Any building, other than a frame building, within the fire limits containing more than 500 gallons of inflammable liquids in other than sealed containers, must have all windows in side and rear walls and above the first floor on street fronts exposed by another building within fifty feet, provided with wired glass in metallic sash and frame.

Section 33. Any manufacturing plant hereafter established in a building in which persons are employed above the second story, shall have all rooms in which Class I and II liquids are mixed or stored in receptacles permitting the escape of vapor constructed as given in Section 29.

Section 34. In existing manufacturing plants where persons are employed above the second floor, all elevator, stair and other wells or vertical openings communicating to rooms in which Class I and II liquids are mixed or stored in receptacles permitting escape of vapor, must be inclosed and provided with automatic fire doors or trap doors.

Section 35. No manufacturing plant shall be located in any building used as a dwelling for more than one family unless all Class I liquids are kept in safety cans, not exceeding one quart in capacity, or in outside storage tanks as given in Chapter III, with no discharge inside the building.

Section 36. Kettles, vats, saturators and other vessels used in manufacturing processes, and containing more than five gallons of inflammable liquid, must not be located within five feet of combustible material nor within five feet of any exit, unless two or more exits are provided, and all combustible floor thereunder within a radius of ten feet must be protected with non-combustible covering. All kettles and other open vessels must be provided with substantial covers operating automatically or which can be easily and readily placed in position.

Section 37. Rooms in which Class I and II liquids are used in open vats, pans or other vessels, or in which Classes I, II and III liquids are heated or otherwise treated in such manner as to produce inflammable vapor, shall be well ventilated. Where natural ventilation is not sufficient, ventilation may be obtained as provided in Section 110, or a trench or trough located in the lowest portion of the room, near any appliance emitting inflammable vapor may be used, such trough to be not less than six inches deep, open except for screens or grating and sloping downward to the outside of the building to a point acceptable to the inspection department having jurisdiction; or a ventilation system or any other special systems meeting the intent of this section may be used when approved by the inspection department having jurisdiction.

Section 38. Where inflammable liquids are kept, used or handled, dry sand, ashes, chemical extinguishers or other fire retardants shall be provided in such quantities and with such pails, scoops and other fire appliances as may be directed by the inspection department having jurisdiction. A reasonable quantity of such loose non-combustible absorbents as mentioned above shall be kept convenient for use in case of excessive oil leakage or overflow.

Section 39. Inside the fire limits, barrels and drums containing Class I, II or III liquids stored outside any building must not be piled upon each other nor stored in a passageway or beneath any window and no open lights shall be permitted in any such storage yard.

Section 40. Drums or barrels for inflammable liquids shall have caps, plugs and bungs replaced immediately after package is emptied.

Section 41. In all rooms or parts of buildings which contain inflammable liquids in open containers or in which the vapors from inflammable liquids are present, or in which inflammable liquids are used in any manufacturing process, the carrying of matches is prohibited, and smoking shall be a misdemeanor. Suitable signs lettered SMOKING PROHIBITED BY ORDER OF THE CHIEF OF THE FIRE DEPARTMENT shall be displayed.

Section 42. Inflammable liquids shall not be drawn nor handled in the presence of open flame or fire, but may be drawn and handled when lighting is by incandescent electric lamps installed in compliance with the rules and regulations of the "National Electrical Code;" said rules and regulations are hereby made a part of the requirements of this ordinance as affecting all electrical equipment.

Section 43. No portable wheeled tank for the handling of inflammable liquids inside buildings shall exceed sixty gallons capacity. Tank must be of iron or steel, 3/16-inch thick, with all openings at the top and screened with 30 x mesh, or equivalent, brass wire screen. Wheels must be rubber tired and tanks so hung as not to be tipped over in ordinary usage. Liquids must be drawn from tank by means of a tight fitting pump or equivalent device which will not permit continuous flow in case of mishap or defective operation.

Section 44. The handling or storing of any inflammable liquid within dangerous proximity to open flame or fire is expressly prohibited.

Storage Tanks—Capacity, Location and Restriction

Section 45. Except as otherwise permitted in this ordinance, the storage of inflammable liquids shall be outside buildings, in underground tanks or above ground tanks; except that the storage in tanks above ground and outside buildings is prohibited within the following limits: (NOTE.—These limits to be specified; they should include the mercantile and other congested districts and land near streams or other water ways which would carry burning liquid into congested districts.)

Section 46. Tanks located underground shall have top of tank at least three feet below the surface of the ground, and below the level of the lowest pipe in the building to be supplied. Tanks may be permitted underneath a building if buried at least three feet below the lowest floor. Tanks shall be set on a firm foundation and surrounded with soft earth or sand, well tamped into place or encased in concrete. Tank may have a test well, provided test well extends to near bottom of tank, and top end shall be hermetically sealed and locked except when necessarily open. When tank is located underneath a building, the test well shall extend at least twelve feet above source of supply. The limit of storage permitted shall depend upon the location of tanks with respect to the building to be supplied and adjacent buildings, as follows:

(a) Unlimited capacity if lower than any floor, basement, cellar or pit in any building within a radius of fifty feet.

(b) 20,000 gallons total capacity if lower than any floor, basement, cellar or pit in any building within thirty feet radius.

(c) 5,000 gallons total capacity if lower than any floor, basement, cellar or pit in any building within twenty feet radius.

(d) 1,500 gallons total capacity if lower than any floor, basement, cellar or pit in any building within ten feet radius.

(e) 500 gallons if not lower than every floor, basement, cellar or pit in any building within ten feet, in which case it must be entirely encased in six inches of concrete.

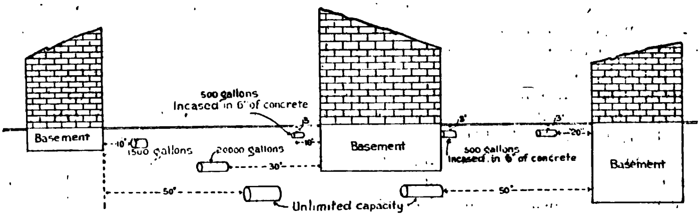

FIG. 1.—SHOWING PERMISSIBLE QUANTITY AS AFFECTED BY LOCATION

EDITOR'S NOTE.—In connection with the requirement for the depth of bury necessary for tanks, the following extract from the *Scientific American*, August 25, 1908, is given, to show that the 3 feet required is ample.

PENETRATION OF HEAT IN EARTH

"The Hanover fire department made a series of experiments for determining the penetration of the soil by the heat of a fire above it. Three broad piles, about three feet high and three feet square, with slopes of 45 degrees, were constructed of dry sand, nearly dry clay, and wet rubbish. On each pile was erected a brick furnace, in which a hot fire of coke was maintained, so that the upper surface of the piles inside the furnaces acquired a temperature of about 2,200 degrees F., which is seldom or never attained by the bottom of a heap of ruins in a conflagration. Thermometers and fusible balls were buried in the piles at depths of 4, 12, 20, 30 and 40 inches below the surface, and were examined hourly.

"It was found that even very thin layers of earth have a great power of thermal insulation. In the pile of rubbish, for example, after the fire on top had been burning 21 hours, the temperatures in Fahrenheit degrees were: 518 at the depth of 4 inches, 185 at 12 inches, 122 at 20 inches, 68 at 30 inches, and 62½ at 40 inches. Moisture was found to retard the penetration of heat very greatly. In the wet pile, at the small depth of 4 inches, the temperature remained at 212 degrees F. (the boiling point of water) until the moisture had been almost entirely evaporated.

"At the depth of 20 inches, 46 hours of firing were required to raise the temperature to 158 degrees F., the average boiling point of commercial gasoline, and at 40 inches below the surface only a very small rise of temperature was produced by 70 hours of brisk firing.

"Hence it appears quite sufficient to put the highest part of the gasoline reservoir 20 inches below the surface of the ground, for, apart from the improbability that a surface temperature of 2,200 degrees F. will be maintained during 46 hours as the result of a conflagration, gasoline could not be caused to boil by a temperature of 160 or 170 degrees F., produced by a fire above, because of the cooling of the reservoir by the colder strata of earth below.

"The cause resulting in this test was the great fire in the Victoria Warehouses in Berlin, where more than 30,000 gallons of gasoline, stored in an underground reservoir, lay under a pile of burning ruins for twenty-four hours. The explosion, or even the combustion of this quantity of gasoline, would have entailed a great direct loss, and would also have given the conflagration a vastly more serious character."

Section 47. Outside the limits given in Section 45, the capacity of each outside above ground storage tank used, designed or intended for Class I and II liquids shall be limited as given in Column A of Table I. For Class III liquids a storage double that given in Column A, Table I, will be permitted.

EDITOR'S NOTE.—Since the date of issue of this proposed ordinance, approval has been given by the Underwriters' Laboratories to the Erwin foam extinguisher—see page 618, which in the opinion of some authorities is of such value as to permit a closer spacing of tanks than given in these requirements, or about double these permitted quantities for the same spacing.

TABLE I

Capacity of Outside Above Ground Storage Tanks for Class I and II Liquids

COLUMN A	MINIMUM DISTANCE OF TANKS	
Capacity of Tank, Gallons	To Line of Adjoining Property which may be Built Upon*	To Any Other Tank
300 or less	5 feet	2 feet
500 "	10 "	2 "
1,000 "	20 "	2 "
8,000 "	25 "	2 "
12,000 "	30 "	2 "
18,000 "	40 "	3 "
24,000 "	50 "	3 "
30,000 "	60 "	3 "
48,000 "	75 "	3 "
75,000 "	85 "	3 "
100,000 "	100 "	15 "
150,000 "	150 "	25 "
250,000 "	250 "	35 "
500,000 "	300 "	50 "
1,000,000 "	350 "	75 "
Unlimited "	400 "	200 "

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* In general this distance should apply to the distance away from any building, even those in connection with the plant itself, and should in all cases apply to buildings where open flame may be used.—EDITOR'S NOTE.

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Section 48. Each above ground tank, inside or outside buildings, over 1,000 gallons in capacity, must have all manholes, hand holes, vent openings and other openings, which may contain inflammable vapor, provided with 20 x 20 mesh, brass wire screen, or its equivalent, so attached as to completely cover the opening and be protected against clogging. A safety valve must be provided, or manhole covers must be kept closed by weight only, and not firmly attached. The screen on such opening may be made removable, but must be kept normally firmly attached.

Section 49. Above ground tanks for Class I and II liquids outside buildings shall have painted conspicuously upon their side, in letters at least 2 inches high, the wording, "INFLAMMABLE—KEEP FIRE AWAY."

Section 50. Except existing tanks in good condition, all tanks outside buildings, either above or below ground, and all tanks for Class I liquids inside buildings, as permitted by this ordinance, shall be made of galvanized steel, basic open hearth steel or wrought iron of a minimum gauge U. S. Standard depending upon the capacity or size as given in Tables 2, 3 and 4.

TABLE 2

Underground tanks inside the limits prescribed in Section 45, or within 10 feet of a building when outside such limits.

Capacity (Gallons)	Minimum Thickness of Material
1 to 560	14
561 to 1,100	12
1,101 to 4,000	7
4,001 to 10,500	1/4"
10,501 to 20,000	5/16"
20,001 to 30,000	3/8"

TABLE 3

Underground tanks outside limits as described in Section 45, provided the tanks are 10 feet or more from a building.

Capacity (Gallons)	Minimum Thickness of Material
1 to 30	18
31 to 350	16
351 to 1,100	14
1,101 to 4,000	7
4,001 to 10,500	1/4"
10,501 to 20,000	5/16"
20,001 to 30,000	3/8"

TABLE 4

Above Ground Tanks.

(a) Horizontal or vertical tanks not over 1,100 gallons capacity.

Capacity (Gallons)	Minimum Thickness of Material
1 to 30	18
31 to 350	16
351 to 1,100	14

(b) Horizontal tanks over 1,100 gallons capacity.

Maximum Diameter	Minimum Thickness of Material Shell	Heads
Not over 5 feet	10	7
5 feet to 8 feet	7	1/4"
8 feet to 11 feet	1/4"	3/8"

(c) Vertical tanks over 1,100 gallons capacity.

Under 40 feet in diameter and containing not more than 5,000 gallons:

Bottom No. 8 gauge
Bottom Ring No. 8 gauge
Other rings No. 10 gauge
Top No. 12 gauge

Under 40 feet in diameter and containing more than 5,000 gallons but not more than 10,000 gallons.

Bottom No. 8 gauge
Bottom Ring No. 7 gauge
Other rings No. 8 gauge
Top No. 12 gauge

Other vertical tanks to be of thickness not less than indicated in the following table, the figures referring to U. S. Standard gauge:

DIAMETER	Top	Top Ring	2d Ring from Top	3d Ring from Top	4th Ring from Top	5th Ring from Top	6th Ring from Top	Bottom
Feet								
80	10	7	7	3	0	3–0	5–0	10
75	10	7	7	4	1	2–0	4–0	10
70	10	7	7	4	1	2–0	4–0	10
65	10	7	7	5	1	0	3–0	10
60	10	7	7	5	2	0	2–0	10
55	10	7	7	6	3	1	2–0	10
50	10	7	7	7	4	1	0	10
45	10	7	7	7	5	3	1	10
40 and less	10	7	7	7	5	3	2	10

All riveted joints to have an efficiency of at least 60 per cent.

Tanks of greater capacity than given above shall be of material of sufficient thickness to safely hold the contents, and proportionately heavier. No vertical tanks shall be more than 30 feet high.

Section 51. With the approval of the Inspection Department having jurisdiction, tanks of copper or other suitable material may be used, if after the necessary handling incident to installation they conform to the value given above as to strength, rigidity, durability and tightness.

Section 52. Tanks shall be riveted, welded or brazed, and shall be soldered, caulked or otherwise made tight in a mechanical and workmanlike manner, and if to be used with a pressure discharge system shall safely sustain a hydrostatic test at least double the pressure to which tank may be subjected. Top of tank to be securely fastened to top ring, with joints of equal tightness to those between rings. They shall be covered with asphaltum or other non-rusting paint or coating. All pipe connections shall be made through flanges or reinforced metal securely riveted, welded or bolted to tank and made thoroughly tight.

Section 53. Tanks must be set upon a firm foundation, and outside tanks when above ground, except portable tanks, must be electrically grounded.

Tanks more than one foot above the ground must have foundation and supports of non-combustible materials, except wooden cushions; no combustible material shall be permitted under or within ten feet of any above ground outside storage tank.

Tanks containing crude petroleum shall be surrounded by an embankment or wall of sufficient height to provide storage equal to one and a half times the capacity of the tank.

Section 54. Stationary tanks inside buildings for the handling of liquids of Classes II and III, where permitted in this ordinance, shall be made of soft galvanized iron, or tin plate suitable for the purposes. Cylindrical tanks of 120 gallons or less capacity shall be made of material with a minimum thickness of No. 20 gauge U. S. Standard; rectangular tanks of 800 gallons or less capacity shall be made of material with a minimum thickness of No. 14 gauge U. S. Standard. Correspondingly heavier gauge metal must be used for longer tanks. All joints must be locked, double seamed or riveted. All joints must be soldered or made tight by some equally satisfactory method. All such tanks shall be so located that the pump or other drawing off device shall not be below the first floor, and the floor for a radius of at least three feet from pump shall be of non-combustible materials or covered with metal. Tanks similar to those given in Section 50 may also be used, or original barrels or drum may be used until contents are drawn, if substantially placed to prevent tipping or rolling, with pump inserted through a close fitting connection in head or side.

Piping and Other Appurtenances

Section 55. All connections from tank to any house or sub-surface drainage system shall be so arranged as to prevent the flow of inflammable liquid to any such system or the leakage of any inflammable gases from such fluid, or properly constructed inflammable fluid collectors shall be provided in such connection.

Section 56. All underground storage systems or Class I liquids, in which the tank may contain inflammable gases, shall have at least a 1-inch vent pipe, run from top of tank to a point outside of the building and acceptable to the Inspection Department having jurisdiction, but which shall end at least 12 feet above level of source of supply and in a location remote from fire escapes and never nearer than three feet, measured horizontally and vertically, from any window or other opening, the tank vent pipe shall terminate in a goose-neck protected in the outer end by a 30 x 30 mesh or equivalent brass wire screen. Or a combined vent and filling pipe, so equipped and located as to vent the tank at all times, even during filling operations, may be used. The vent pipes from two or more tanks may be connected to one upright, provided they be connected at a point at least one foot above level of source of supply.

Section 57. All drawing-off pipes terminating inside of any building shall have valve at the discharge end; when delivery is by gravity, pipes shall have valve, which shall preferably be of the automatically closing type, and in addition must have emergency valve.

Section 58. Where tanks are above ground there shall be a valve located near the tank in each pipe. In case two or more tanks are cross-connected there shall be a valve near each tank in each cross connection.

Section 59. Pumps delivering to or taking supply from above ground storage tanks shall be provided with valves on both suction and discharge side of pump, and check valve when delivering to tank.

Section 60. Where underground tanks are used, all pipes carrying volatile inflammable fluids, except in dry-cleaning establishments, shall pitch toward tanks without any traps or pockets, and shall enter tank at the top.

Section 61. All pipes used in systems for inflammable liquids shall be of standard full weight brass, galvanized iron or steel, with suitable brass or galvanized malleable iron or steel fittings, or of double wall lead with an inert gas in the annular spaces between wall at all times the inner pipe contains inflammable liquid. No rubber nor other packings, and no flanges, shall be used. If unions are used, at least one face must be of brass, with close fitting conical joints. Litharge and glycerin, shellac or other suitable material shall be used on pipe joints. Outside piping must be protected against any mechanical injury when within 5 feet of ground level. Inside piping must be rigidly supported.

Section 62. Defective and leaking piping must be made tight immediately or replaced.

Section 63. Piping carrying Class I and II liquids, unless without joints or connections, shall not extend through any room which contains any open light or fire.

Section 64. The end of the filling pipe for underground storage tanks for Class I and II liquids shall be carried to an approved location outside of any building, but not within 5 feet of any entrance door, or cellar opening, and shall be set in an approved metal box with cover which shall be kept locked except during filling operations; this filling pipe shall be closed by a screw cap. A 30 x 30 mesh or equivalent brass screen strainer shall be placed in the supply end of filling pipe.

Section 65. Deliveries of inflammable liquids of Class I and II, where practical, shall be made directly to the storage tank through the filling pipe by means of a hose or pipe between the filling pipe and barrel, tank wagon or tank car from which such liquid is being drawn.

Section 66. Except as permitted in Section 68, inflammable liquids shall be drawn from tanks by pumps so constructed as to prevent leaking or waste splashing, or by some other system approved by the Inspection Department having jurisdiction, with controlling apparatus and piping so arranged as to allow control of the amount of discharge and prevent leakage or discharge inside the building by any derangement of the system. When inside a building, the pump or other drawing-off device shall be located on or above the grade floor, preferably near an entrance or other well-ventilated place.

Section 67. Except as permitted in Section 68, no tanks, drum nor other containers inside a building, or discharging inside a building, shall be provided with a faucet or other bottom-drawing device which will permit the gravity flow of liquids inside the building. Pipe shall not terminate at any point lower than the level of source of supply.

Section 68. The Inspection Department having jurisdiction shall permit the storage and gravity flow of inflammable liquid in refineries and in manufacturing and jobbing plants where the nature of the manufacturing process requires such storage and flow, and also the storage and gravity flow of commodities of Classes II and III in stores, plants and establishments, where the nature of the liquid will not permit pumping. Provided that the contents of tanks holding Class I liquid shall be sufficient only for one day's operation and such storage shall be in rooms as called for in Section 29.

Section 71. Pumps must be equipped with a pressure gauge for oil and the system shall be so arranged that the oil pressure cannot at any time exceed 60 pounds, a relief valve to be provided to return surplus oil back to the supply tank when the pressure exceeds this quantity.

If receivers, accumulators or standpipes are provided, they must be so arranged that the oil may drain back to the supply tank.

Section 78. Containers of petroleum Class I and II liquids shall be painted red and be conspicuously lettered in black, "Dangerous—Keep Lights and Fires Away and Store Outside Building." Containers of Class III liquids shall be painted green and have conspicuously marked in white letters, "Inflammable Liquid—Keep Fire Away and Store Outside Building." It shall be a misdemeanor to keep or place the above mentioned liquids in containers other than those marked as designated, or to use the containers for any other liquids or substances than those specified, or fail to keep their exterior clean so that coloring and lettering are easily distinguishable.

Garages

Section 85. A garage shall be construed to mean a building in which are housed, for rent, care, demonstration, storage or sale, self-propelled vehicles or other wheeled machines, containing in the tanks thereof inflammable liquids for fuel or power; also all parts of the building and all adjoining structures or buildings not cut off by an unpierced fire wall.

Section 86. No garage shall be allowed or kept in any building used for a school, place of assembly or detention, hotel, apartment, tenement or lodging house, or within 50 feet of any school, place of assembly or detention. Any building erected or remodeled as a garage and occupied in part as an office building, manufacturing establishment, warehouse or store, shall have such parts entirely cut off from the portion used as a garage, by unpierced fire walls at least 12 inches thick and by fireproof floors, and shall be provided with adequate means of exit independent of that used for the garage. All windows in the first two floors above parts used as a garage shall be provided with wired-glass windows in metal frames.

Section 88. All garages erected in the future, except as hereinafter specified as private garages, shall be of fireproof construction. All trim or other interior finish must be of metal or of other non-inflammable material approved by the Building Inspector. Floor finish shall be smooth and of concrete, brick or other incombustible material.

Section 89. No rooms, nor open or closed spaces of any character, shall be permitted below the floor level in any building erected or used for garage purposes, and no floor shall be entirely below the street level.

All elevators and stairways in garages shall be enclosed with fireproof materials. All openings in stair or elevator enclosures shall be protected with automatic fire doors approved for this purpose.

Section 91. Where buildings are now being used for garage purposes, in which wooden floors exist, sufficiently large and fluid-tight metallic drip pans shall be placed under all motor vehicles, and all floors shall be well cleaned and mopped each day with a strong alkali or other non-inflammable grease solvent solution.

Section 92. All automobile garages or shelters housing not more than three motor vehicles shall be known as private garages. A private garage located within 10 feet of any other building must be of fireproof construction as called for in Section 88. If more than 10 feet from any building, it must be built of non-combustible material throughout, except that, if outside the fire limits and not closer than 30 feet to any building, it may be constructed of combustible material, except walls, floors on which automobiles are kept and roof coverings, which shall be non-combustible. All portions of the building used for other purposes must be cut off from such storage place by unpierced fireproof walls and floors.

Section 93. The heating for all buildings used for garage purposes must be done by steam or hot water. All boiler or other furnaces, forges or other exposed fires, lights or spark-emitting devices or machines, and all repair shops, if on or below the topmost floor where Class I liquids are present, must be in a room separated from all other parts of the garage by an unpierced fire wall at least eight (8) inches thick. Such appliances may be kept in the garage if in a fireproof room 8 feet above the top-most floor where Class I liquids are present, provided all doors and openings between such rooms and other parts of the garage are provided with standard self-closing fire doors kept closed. All such rooms must be ventilated at floor line as described in Section 97. Lighting shall be as given in Section 42. No flame lights shall be allowed lit on automobiles in a garage except immediately after entering and immediately before leaving the garage.

Section 94. All reserve and storage of Class I and II liquids must be stored in underground tanks. No Class I liquid shall be kept inside a garage except that contained in the reservoirs of motor vehicles and in the measuring pumps used for filling; provided, however, that there may be in each garage one or more approved portable wheeled tanks not exceeding sixty gallons capacity, to be used for transferring such liquids from the storage tank. The reservoirs of motor vehicles shall be filled directly through hose from pump attached to such portable tank, or by hose coupled to a permanent filling station connected with the main storage tank. No transfer of Class I or II liquids in any garage shall be made with open containers. Hose for use in connection with the permanent filling station or portable tank shall be of such design and material as to prevent leakage. The portable wheeled tank must be as described in Section 43.

The use of gasoline for cleaning any parts of an automobile is prohibited, except in a special room as provided for in Section 29, and ventilated as given in Section 37, and used for this purpose only, or outside of any building and at least 10 feet from any opening in any buildings.

Section 95. All underground tanks shall comply with the requirements given in Sections 46, 50, 51 and 52.

Section 96. Pumps and other drawing-off appliances shall be as given in Sections 55, 56, 57, 60, 61, 63, 64, 65 and 66. The drawing of any inflammable liquid within dangerous proximity to exposed flame or fire, or while any automobile engine or motor is being run in the room, is expressly prohibited.

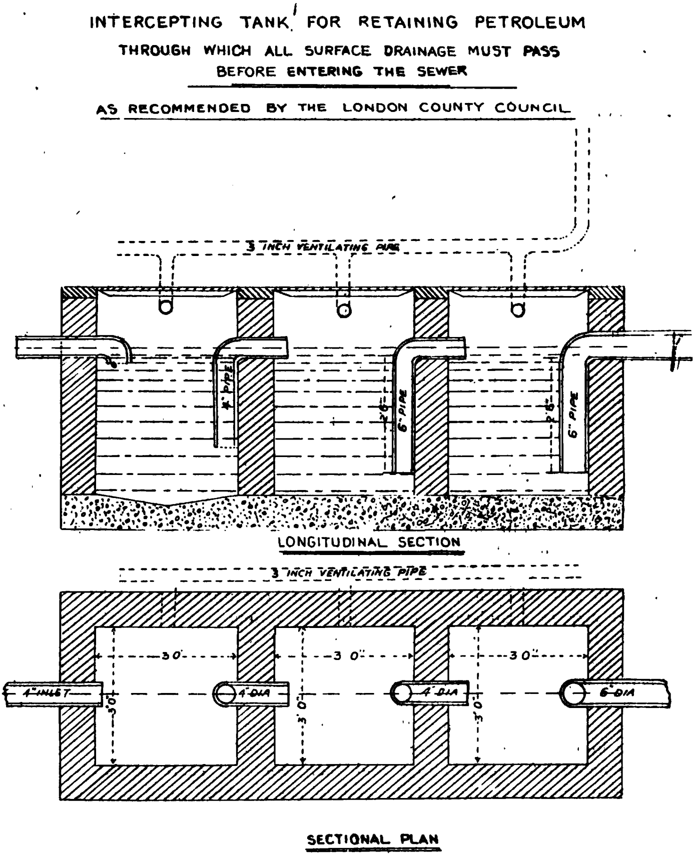
Section 97. Rooms containing Class I and II liquids shall have openings for ventilation, of at least 30 square inches, along at least two walls and at floor level. These openings shall connect by incombustible flues to the outside air at a point not closer than 3 feet to any window or door opening. They shall be provided with 2 x 2 mesh brass wire screen on the inside of the wall, and unless laid with a downward slant direct to the outside air, shall conduct to and through a sparkless fan, run continuously, which shall be of sufficient size to completely change the air volume every ten minutes. Discharge outlets of vent pipes shall be provided with 20 x 20 mesh (or equivalent) brass wire screens.

Section 98. All garages must be kept clean. Grease, oil or paint-soaked rags, waste or other combustible materials of like character, shall be kept in approved self-closing metallic receptacles having metallic legs at least 3 inches high and securely braced. These receptacles shall be kept safely clear of all combustible surroundings and their contents shall be safely disposed of at least once each day. Oily and greasy clothing shall be cared for in non-combustible and well-vented closets, safely located.

Section 99. Class III liquids may be kept inside the buildings, if stored as given in Section 54. The style of can and its location must be approved.

Section 100. Dry sand, ashes, chemical extinguishers and other approved fire retardants shall be provided in such quantities and with such pails, scoops and other fire appliances as may be directed. A reasonable quantity of such loose, non-combustible absorbents as mentioned above shall be kept convenient for use in case of excessive oil waste or overflow.

Section 101. There shall be no direct connection between any garage waste basin, sink, floor drain or waste and any house drainage or sewer system. All such drains or waste mains to sewer system shall have inter-



INTERCEPTING TANK FOR RETAINING PETROLEUM THROUGH WHICH ALL SURFACE DRAINAGE MUST PASS BEFORE ENTERING THE SEWER

AS RECOMMENDED BY THE LONDON COUNTY COUNCIL

FIG. 2.

cepting grease, oil and inflammable liquid traps or separators which will completely separate such substance from water and sewage and allow of their safe and convenient removal. Such traps shall be ventilated in the same way as is required for tanks holding Class I liquids.

Section 102. It shall be the duty of the owner or manager of all garages to maintain in at least three conspicuous places on each floor of a garage a placard giving a copy of all ordinances affecting the handling of inflammable liquids in garages.

In recent years, practically all the large cities have had violent explosions in sewers; the evidence in many of these cases has been such as to indicate that these were caused by an accumulation of gasolene vapor or vapors from other oils. Several cities have rigid requirements to prevent the discharge into sewers. Fig. 2 gives details of a large separator designed in England and Figures 3 and 4 give details of one in use in New York. The requirements of this last are as follows:

Oil Separators of the New York Fire Department

BILL OF MATERIAL.—See Figure 3. Two 3/16-inch steel tanks rivetted together, composed of one large tank, 24 inches by 30 inches by 60 inches, having rivetted to its intake end, the small tank 22½ inches by 12 inches by 34 inches (end of large tank comprises division wall). Top of small tank on same level with that of large one.

SMALL TANK.—Either a steel or cast-iron hopper bottom rivetted to small tank, about 9 inches deep by 22½ inches by 12 inches.

1 3-inch plug valve (brass plug—iron body).
1 box wrench to fit 3-inch plug valve.
1 connecting nipple (to connect 3-inch plug valve to hopper bottom).
1 4-inch threaded I. P. flange rivetted to tank.
1 4-inch by 6-inch nipple (threaded for its entire length).
1 4-inch by 6-inch I. P. S. nipple.
1 4-inch Tucker connection.
1 4-inch cast-iron elbow.
One 5/16-inch steel plate cover, two lifting rings connected.
2-inch x 2-inch x ¼-inch steel angles rivetted all around inside near top for cover.
One 1/16-inch asbestos gasket.

LARGE TANK.—One 2-inch threaded I. P. flange rivetted to large tank (for vent pipe).

One 2-inch x 7-inch nipple, I. P. S.
One 2-inch elbow, 90 deg.
One 1½-inch threaded I. P. S. flange rivetted to tank.
One 1½-inch stop cock, for iron pipe (brass plug—iron body).
One 1½-inch x 1¾-inch nipple.
One box wrench to fit 1½-inch plug valve.
One 4-inch I. P. S. flange rivetted to tank (outlet).
One 4-inch x 5-inch nipple I. P. S.
One 4-inch C. I. standard T-fitting.
One 4-inch C. I. plug for T-fitting.
One piece 4-inch wrought iron pipe, 29 inches long, threaded both ends.
One 4-inch C. I. standard 45-deg. elbow.
One 4-inch C. I. standard plug for 45-deg. elbow (⅛-inch hole drilled in top for syphon breaker).

One 5/16-inch steel plate cover with 2½-inch x 2½-inch x ⅜-inch stiffener attached.

2½-inch x 2½-inch x ¼-inch angle rivetted to inside, all around near top for cover.

Two lifting rings rivetted to cover.

One 1/16-inch asbestos gasket.

SPECIFICATIONS.—3/16-inch steel throughout, except covers.

Rivets ½-inch diameter, 2 inches C. to C.

No soldering allowed.

Electric or acetylene welding permitted.

All joints to be caulked, where rivetted.

To be gas and water tight.

All flanges to be rivetted or electric or acetylene welded to shell.

Outside of separator to be coated with a rust proof coating.

INSTALLATION.—Oil separators installed in any building where volatile inflammable fluids are used, must be arranged to be *readily accessible;* where located underground an iron, brick or concrete manhole must be provided with an iron or flagstone cover. They must not receive the discharge of house, outside court and area drains, toilets or leaders.

They must in all cases be connected by a Y-branch fitting to the house sewer on the public sewer side of house trap.

No separate trap need be provided on drain entering oil separators, but a running trap must be provided for each floor drain discharging to the separator.

When fixture of floor drains are located on any floor above the first, the lines to which they are connected must extend in full calibre at least one foot above the roof coping, and well away from all shafts, windows, chimneys or other ventilating openings. When less than 4 inches in diameter they must be enlarged to 4 inches at a point not less than one foot below the roof surface by an increaser not less than 9 inches long, and the traps of all fixtures vented.

Relief pipes must be provided at least 2 inches in diameter and carried independently above the roof and there capped with down-turned elbow equipped with fire screen.

Drainage from washstand in garages shall not be permitted to flow into sump pits.

All piping must be left exposed until after the Fire Department inspections.

Oil separator pit should be so located to prevent floor drainage flowing into it, or else have concrete curbing around it.

When a pit is below the ground water table and there is a possibility of water being in the pit, the lining should be made impervious.

(See Figure 4 for Underground Installations.)

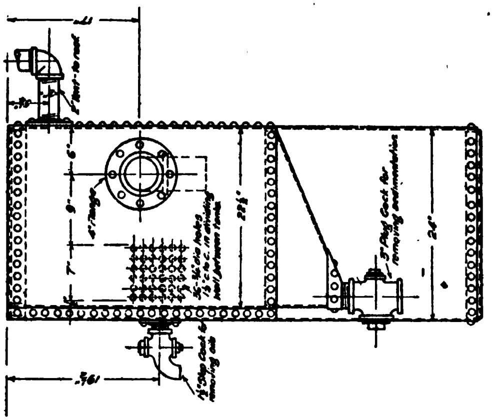


FIGURE 3(b)

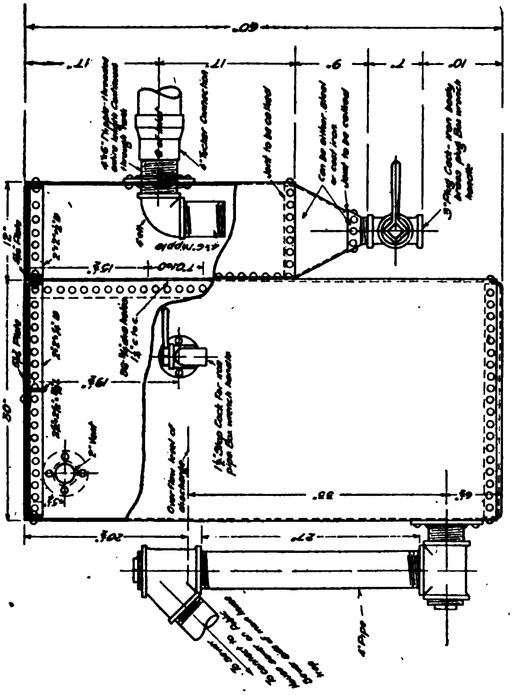


FIGURE 3(a)

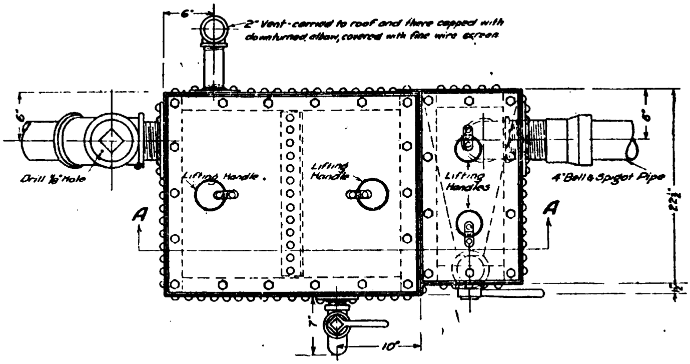


FIGURE 3(c)

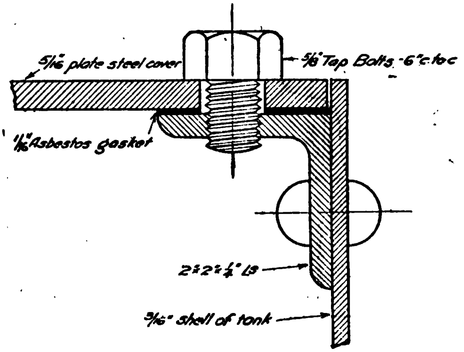


FIGURE 3(d)

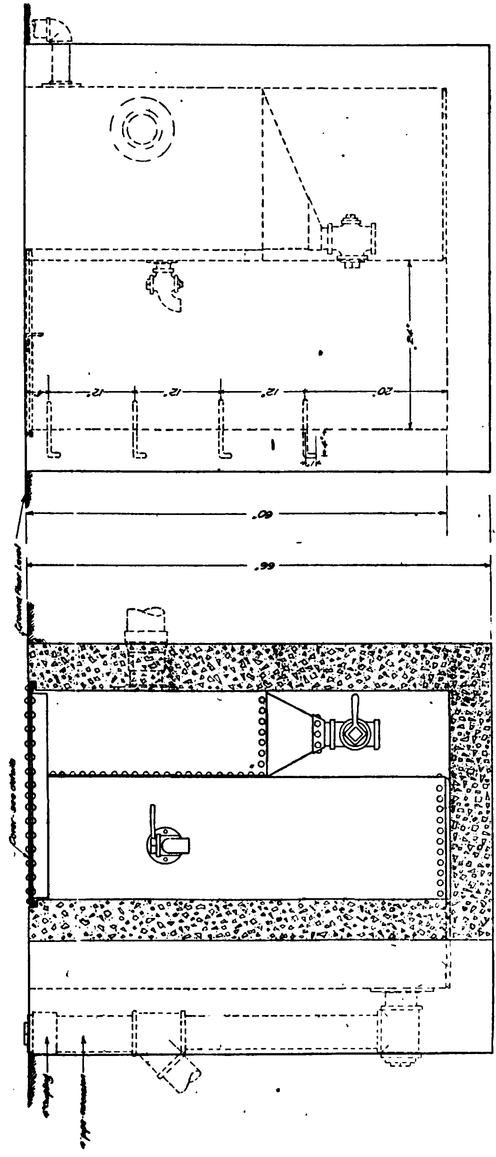


FIGURE 4(a)

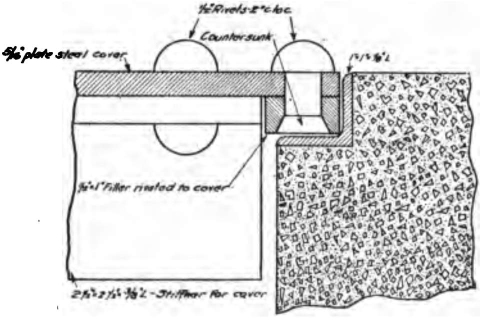


FIGURE 4(b)

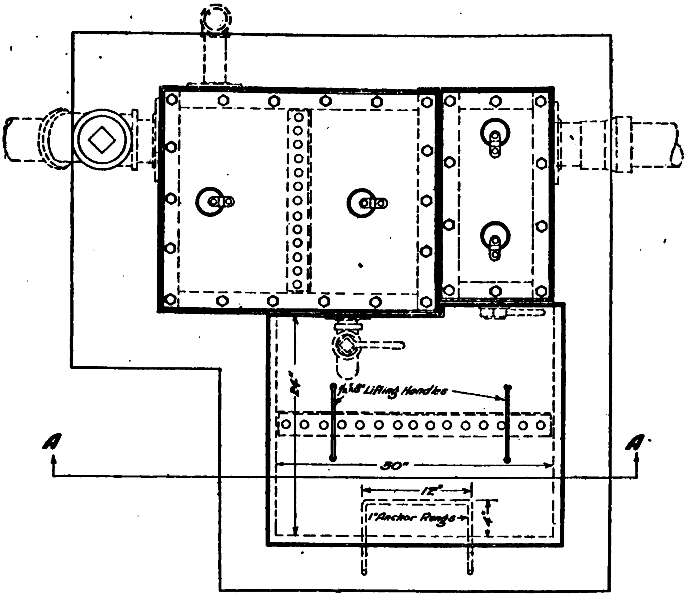


FIGURE 4(c)

Dry Cleaning*

Section 103. "Dry cleaning" shall be known as the art, act or process of cleaning or renovating wearing or other apparel, clothes and other fabrics or textiles, or any other things with any inflammable liquid. "Sponging" shall be the removal of dirt, grease, etc., by local application of inflammable liquid as applied by tailors and others.

Section 104. Sponging is prohibited in shops, dwellings, enclosures, yards and all other places, unless carried on through the application of such inflammable liquids from an automatically closing safety can of not more than one (1) quart capacity, and the use for sponging of such liquid from, or in, open pans or vessels shall be a misdemeanor.

Section 105. Sponging is prohibited in any room not provided with safe means of exit direct to the outside of the building and shall not be executed or applied in any room or enclosure containing any open or flaming fire or light nor within ten feet of any such light, self-heating iron or other spark or flame producing appliance. During all such application, and for one half hour thereafter, two direct openings for ventilation and air circulation must be provided, preferably on opposite sides of the room and near the floor level.

Section 107. Buildings used for dry cleaning purposes shall be constructed of non-combustible material, shall not be more than one story or 16 feet high, without a basement or other open space below the floor, shall not be used for other occupancy, and shall be at least 10 feet from other buildings or a public thoroughfare. All floors shall be of concrete or other non-combustible material. All doors shall have raised sills at least 10 inches above the highest point of floor, and no other opening, except for ventilators, shall be less than 12 inches above same point. In wash rooms, only the necessary appliances for washing, extracting and redistilling shall be permitted. No direct opening shall be permitted between wash room and dry room. No combustible material shall be permitted in the construction of dry rooms or any racks or other appurtenances. All steam or hot water pipes for drying purposes must be protected by wire screens or otherwise so as to prevent contact of pipes and inflammable goods. All windows, doors or other openings within 100 feet of exposing openings or combustible structures or materials shall be provided with wired glass in metal frames or fireproof shutters, doors or covers. All doors, windows, shutters, screens, grills and barrel openings shall be arranged for ready opening from either side in case of an emergency. Inter-communicating openings shall be provided with standard automatic closing fire doors kept closed except when passing through. All rooms shall have a steam extinguishing system or where such fire extinguishing agent is not available an approved system using a fire deterrent chemical or gas. One approved hand chemical extinguisher shall be provided for each 500 square feet of floor area.

Section 108. A vent opening of at least 20 square inches area shall be provided at the floor level in each wash room and drying room, near each machine and opposite to any door or other air inlet: such openings shall be covered with 2 x 2 mesh No. 16 galvanized wire web and shall be kept clear of all obstructions. From the vent opening a flue of at least 20 square inches area and of non-combustible materials, built into the wall or floor or securely fastened thereto and free from mechanical injury, shall conduct to and through a sparkless exhaust fan, to be run continuously, and which shall be of sufficient size to completely change the air volume every five minutes. All discharge outlets of vent pipes shall be provided with 12 x 12 mesh or equivalent wire screen and located without hazard to surrounding property. Skylights and windows must be of wired glass in metal frames and provided with fusible link connecting to an automatically closing device, and shall be covered with 12 x 12 mesh or equivalent brass wire screen to prevent spark or other fire entrance. Necessary precautions shall be taken to prevent the clogging or in any way the stopping of air passage through such wire screens.

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* Part of Suggested Ordinance issued by the National Board of Fire Underwriters. References by section number are to the sections on pages 136 to 149.

Section 109. Heating shall be done by steam or hot water. No steam boiler, furnace nor exposed fire, nor any electric dynamo nor motor, nor other spark emitting device, shall be allowed in any washing, drying or distilling room, or in line with vapor travel therefrom. All artificial lighting shall be in accordance with Section 42.

Section 110. In each wash room there shall be provided a drain or connection to the sewer, at least 4 inches in diameter, provided with a U pipe forming a water seal to prevent the passage of inflammable vapor, and with inlet pipe in the form of an inverted U, or a siphon, with end at least 2 inches above the floor lever, ⅛-inch air inlet 3 inches above floor level, and top of siphon 8 inches above floor level.

Section 111. All dry cleaning, washing, extracting and redistilling shall be carried on in closed machines, which shall be fluid tight. Washers shall have hinged door and shall be arranged so that in case of an explosion the door will automatically close. The transfer of all liquids shall be through continuous piping, and all outlet or drain lines shall be drained by gravity to settling or storage tanks. No dry cleaning liquid shall be settled in any open or unprotected vessels or tanks. All piping and all metallic parts of each machine shall be properly grounded by at least No. 10 copper insulated wire to a water pipe or other grounded devices.

EDITOR'S NOTE.—Substances like cotton, linen, wool and silk become electrified when moved quickly in gasoline, and the gasoline, a bad conductor, accumulates the electricity and when equalization arrives produces sparks which ignite the gases.

Section 112. All reserve and storage stocks of such liquids shall be kept and handled as given in Sections 46, 50, 51, 52, 55, 56, 57, 60, 61, 63, 64, 65 and 66.

Section 113. All goods removed from washer to extractors must be kept in tight metal pans with under side of bottom covered with wood, and no goods or washed stocks shall be taken from wash room till washing liquid has been removed by the extractor and all dried goods shall be removed from extractors at close of operation.

EDITOR'S NOTE.—It is reported that many fires start at the centrifugal extractor, from friction or sparks generated by the brake; daily attention should be paid to this and care taken to have complete ventilation at that point.

Section 114. Settling tanks shall be constructed, located and vented essentially as given for the storage tanks. At the close of the day's operations, all liquid contained in washers, extractors or stills, or otherwise, shall be returned to the stock or settling tanks. The location of all tanks buried or otherwise, and their contents and hazards, shall be plainly marked by signs as approved by the Chief of the Fire Department.

REGULATIONS FOR THE CONSTRUCTION AND INSTALLATION OF DIP TANKS*

The process of dipping articles in tanks containing inflammable mixtures should be carried on in a detached building used for no other purpose, located at a safe distance from other property. It is impossible to entirely eliminate the dip-tank hazard where inflammable liquids are used, even though all practicable safeguards are provided.

If the dipping process is permitted inside the main building or in an adjoining building, the room in which the hazard exists should preferably be on the lowest floor, but not below the grade line, nor on a floor immediately above a cellar or basement, and should be used only for dipping processes. Side walls and ceiling of the dipping room to be of fireproof construction at least equivalent to eight inches of brick. There should be a standard fire wall cutting off the room from the rest of the plant; the floor should be fireproof and waterproof; it should pitch to a point at which is located a drain pipe leading outside the building and terminating at a point where liquids flowing therefrom will not endanger surrounding property. The drain pipe to be at least 6 inches in diameter and to have a coarse strainer (about ¾-inch mesh) at floor. No drain-pipe connection shall be made to a sewer. The floor should be 6 inches lower than the floors of adjoining rooms, or the thresholds should be raised that distance and partitions should be flashed so as to guard against inflammable liquids flowing to adjoining rooms. Metal covering for floor is not advised. The room should be well ventilated at top and bottom by suitable screened openings.

NOTE.—In large dip-tank installations a more positive system of ventilation will be necessary.

When practicable a metal hood should be located directly over each tank; hood to terminate in a metal pipe discharging into a properly constructed chimney used for no other purpose. The hood to extend well over the sides and ends of the tank and to be sufficiently low to prevent water from being thrown into the tank from automatic sprinklers. The hood and pipe should be designed to take off flames from the burning liquid in case the automatic cover should fail to operate.

Requirements for Dip Tanks

1. CONSTRUCTION.—To be constructed in a substantial manner of steel or of cast iron. The edges of tank, tracks (when used in connection with covers), and all working parts, to be so constructed and shielded as to protect same against mechanical injury and accumulation of drippings sufficient to interfere with the operation of the cover.

2. COVERS.—Covers may be either hinged or sliding on tracks and should be normally held open by approved types of metal chains containing fusible links, one such link to be near top of tank and one at the ceiling above the tank. Such covers may be constructed either of metal, not less than No. 12 U. S. gauge, reinforced by an angle iron frame, or of two-ply ⅞-inch tongued and grooved board nor over 6 inches in width and covered on all surfaces with lock-jointed tin, and in all cases such covers must overlap the side and ends of tank at least two inches.

All covers to be so designed and installed that operation will be automatic and secure positive closing without danger of sticking when released by action of heat on the fusible links or by manual operation. Covers to be closed when tanks are not in use. Hinged covers to be secured with strong metal hinges offset and protected against gumming.

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* Issued by the National Board of Fire Underwriters, 1913.

Covers operating by gravity on tracks, to be provided with deep and wide grooved wheels, properly shielded so as to prevent accumulation of drippings on them or their tracks, and to be provided with a guard to prevent the wheels leaving the tracks. The inclination of the tracks on this style of gravity cover to be not less than ¾ inch to the foot.

3. DRIP BOARDS.—Each tank to be provided with drip boards to protect working parts of cover and return all drippings to the tank. Boards to be of incombustible material and readily permit of cleaning.

4. AGITATOR.—Each tank containing liquids holding material in suspension should be provided with an agitator or other facilities designed to effectively prevent sediment accumulating and hardening on the bottom of the tank.

5. OVERFLOW.—Tank to have an iron or steel overflow pipe leading outside of building to a cistern. Pipe to be without traps or unnecessary bends and to lead as directly as possible to the cistern. This pipe to be at least 3 inches in diameter when the tank holds less than 100 gallons and increased proportionately for larger tanks. Overflow to have a coarse strainer at tank (about ¾-inch mesh).

6. DRAINS.—Each tank should preferably be provided with a drain pipe of sufficient size to empty tank in about sixty seconds. The drain to be provided with a valve capable of being operated both manually and automatically. The valve opening should be at least 60 per cent larger than the cross sectional area of the drain pipe. The operation of the valve should be sufficiently positive to overcome any danger of sticking or clogging due to the accumulation of sediment. The drain valve to be so designed that when open, it will not interefere with the agitator, and so that the agitator will effectually assist in keeping the passage to the drain valve clear of sediment. Drain pipe to connect directly or through overflow pipe to a cistern.

7. CISTERN.—To be of sufficient size to hold the aggregate capacity of all tanks emptying into it. To be detached at least thirty feet and located in ground sloping down from buildings, or to be so arranged that any overflow cannot endanger property; otherwise the cistern must have at least twice the capacity of all the dip tanks draining into it, and be substantially constructed of masonry, or metal, so as to be watertight. Such cisterns to be buried underground, covered and otherwise arranged to prevent filling of same with water. A proper vent must also be provided. Overflow and drain pipes to dip under water and terminate near bottom of cistern.

8. CARE AND ATTENDANCE.—a. Heating to be done only by steam or hot water. No steam boiler, furnace or exposed fire, nor any electric dynamo or motor or other spark emitting device, to be allowed in any room used for dipping processes or dangerously exposed thereto, or in line with vapor travel therefrom.

b. No open light or flame shall be allowed in any such room, and for electric lighting, lamps shall have keyless sockets and be protected by vapor-tight outer globes. Switches shall be placed outside of room and beyond the presence of ignitible vapors, and the whole shall be done according to the National Electrical Code.

c. All such rooms to be provided with a high pressure steam line fed from a boiler of sufficient capacity to admit of flooding the rooms with steam in case of fire. Operating valves to be located outside building. Any other method of protection judged to be equivalent may be used.

REGULATIONS FOR THE INSTALLATION AND USE OF INTERNAL-COMBUSTION ENGINES (GAS, GASOLINE, KEROSENE, FUEL OIL) AND OF OIL BURNING EQUIPMENT*

Gas Engines

1. Location of Engines.—(a) Should, whenever possible, be located on the ground floor.

(b) In workshops or rooms where dust or inflammable flyings prevail, the engine should be enclosed in a suitable compartment well ventilated to the outer air at floor and ceiling.

(c) If located on a wooden floor, the floor under and 24 inches outside of the engine should be covered with metal.

2. Piping.—(a) Must be provided with a shut-off valve located in an accessible place on the service side of the pressure regulator.

(b) Piping and connections shall be run as direct as possible and be thoroughly tested before being placed in service.

3. Igniter or Exploder.—Electric ignition only must be used.

Note.—Hot tubes and any provision for their installation on engines are prohibited.

4. Muffler or Exhaust Pot.—(a) Exhaust pots must be placed on firm foundations and mufflers and exhaust pots to be kept at least one foot from woodwork or combustible materials.

(b) Exhaust pots of the closed type must be provided with plugged opening, placed near the bottom and below the exhaust pipe connection.

5. Gas Bag or Pressure Regulator.—(a) Gas bags, if used, must be enclosed in a substantial gas-tight metal drum, of approved construction, vented to the outer air through a pipe used for no other purpose.

(b) Where not otherwise provided for, regulator should be arranged with an automatic gas shut-off to prevent the flow of gas into the room in case engine shuts down from any cause.

6. Exhaust Pipe.—Exhaust pipe, whether direct from engine or from mufflers, shall, where practicable, be carried above the roof of the building in which the engine is contained, and above adjoining buildings. When buildings are too high to make this practicable, the pipe shall end at least 10 feet from any wall opening.

No exhaust pipe shall be within 9 inches of any wooden lath and plaster partition, ceiling, or other combustible material.

Where exhaust pipes pass through combustible partitions, they shall be guarded by galvanized iron ventilated thimbles at least 12 inches larger in diameter than the pipes, or by galvanized iron thimbles built in at least 8 inches of brickwork or other incombustible material. They shall not under any circumstances be connected into chimneys or flues, except that the pipe may pass up in flues used for no other purpose. No exhaust pipe shall pass through any floor, nor through a roof having wooden framework or covering.

Note.—This pipe is liable to become very hot and should have additional protection where dust or inflammable flyings are present.

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* As recommended by the National Board of Fire Underwriters.

7. Engine Base.—It is recommended that the base be constructed with a groove or channel to prevent lubricating oil from soaking into floors.

8. Lubricating Oil Drips and Pans.—(a) Must be provided when necessary to prevent the spilling of oil.

(b) Cranks and other rapidly revolving or reciprocating parts must be shielded to prevent throwing of oil.

9. Name Plates.—Must be provided with a name plate giving the name of the manufacturer and the trade name of the engine.

10. Care and Attendance.—Due consideration to be given the cleaning of the cylinder, valves and exhaust pipe as often as the quality of the fuel may necessitate.

Stationary Gasoline Engines

In addition to Nos. 1, 3, 4, 6, 7, 8, 9 and 10 of the *Gas Engine* regulations, the following are made for Stationary Gasoline Engines.

Capacity and Location of Tanks.—In closely built districts, or within fire limits, tanks should be located underground; see page 139.

Gasoline Feed-Cup.—(a) Must be arranged to prevent spattering, dripping or exposure of gasoline during operation or with the engine at rest.

(b) Must be provided with an overflow connection draining to the supply tank.

Gasoline Feed-Pump.—Must be of approved type secure against leaks, with check valves located as close to the pump as convenient.

Exhaust Pipe.—Water pockets in exhaust pipes to be provided with suitable means for drainage.

Engine Base.—(a) Must not be used as a storage space for gasoline or other material.

Portable Gasoline Engines

In this class are included so-called "self-contained" engines, mounted on wheels, or on skids, or otherwise so arranged as to be conveniently moved from place to place as the necessities of the service may demand.

These engines are considered more hazardous than stationary engines having separate underground storage tanks, and should not be used as a substitute for stationary engines. Where used, their hazards should be recognized by the inspection department having jurisdiction, and the following rules and precautions should be rigidly observed.

The requirements for *Stationary Gasoline Engines* apply except as to the Tank, which are as follows.

Supply Tanks.—(a) Gravity feed from supply tank to engine is prohibited.

(b) Capacity of supply tank must not exceed the amount of fuel required for 10 hours running full load.

(c) Must be so mounted as to be protected against wear due to jarring and vibrations.

(d) Must be so located, or protected, as to avoid injury from coming in contact with outside objects, as well as to prevent an excessive rise of temperature of the gasoline, due to heat from cylinder or exhaust.

(e) All pipe connections should be made above the highest gasoline level in the tank.

Care and Attendance.—(a) Tanks to be filled during daylight hours only and while the engine is not running.

(b) Tanks to be filled by means of approved safety cans and main gasoline supply to be kept in approved receptables outside of buildings.

(c) Due consideration shall be given to the cleaning of the cylinder, valves and exhaust pipe as often as the quality of the fuel may necessitate.

(d) Portable engines should not be used where dust or inflammable flyings prevail, nor be located near combustible material.

Stationary Kerosene and Fuel Oil Engines

These rules refer to engines using a fuel having a flash point above 100 degrees Fahr. (Abel-Pensky Flash Point Tester.)

In addition to Nos. 1, 4, 6, 7, 8, 9 and 10 of the *Gas Engine Regulations,* the following are made for engines of this type.

STORAGE OR SUPPLY TANK AND PIPING.—In closely built districts, or within the fire limits, storage or supply tanks shall be located underground and tanks and piping shall conform to the requirements given on pages 139 and 144.

Outside of closely built districts or outside of fire limits, aboveground storage or supply tanks may be permitted, but such tanks and piping shall conform to the requirements given on pages 141 and 144.

AUXILIARY TANKS.—(a) Tanks or other reservoirs for providing a supply of oil within the building to have a capacity of not more than sixty gallons when not of the pressure type. Tanks to be filled by means of an approved pump connected by full weight iron or steel pipe to the main supply tank. To be provided with an ample overflow pipe connected to main tank. Oil to be drawn from auxiliary supply by means of an approved pump operated by the engine. Gravity feed of oil to engine or pipe connections below the oil level in auxiliary tanks having a capacity in excess of one gallon is not to be permitted.

(b) Tanks or receivers of the pressure type to have a capacity of not over ten gallons and to be provided with a reliable gauge. This tank also to have an approved pressure relief set to operate at a safe pressure and connected by an overflow pipe to the main tank. These receivers, when arranged with engine supply pipe connections below the oil level, to be so arranged that the oil will automatically drain back to the main supply tank when the engine stops, leaving not over one gallon, where necessary for priming. In case the supply of oil for the engine by piping is connected above the oil level the automatic release of the pressure without the draining of the oil may be permitted.

EDITOR'S NOTE.—At a meeting of the National Fire Protection Association in May, 1916, the above section on Auxiliary Tanks was recommended to be changed as given below; action by the National Board of Fire Underwriters had not been taken at the time this book went to press:

Auxiliary Tanks, Standpipes, Receivers or Accumulators.—a. These may have a total capacity of 60 gallons, and may be of an individual capacity not exceeding 60 gallons, if the containing room is fireproof, not used for other manufacturing or storage purposes and provided with standard wall opening protection on all interior and exterior walls.

b. In room other than described above, the capacity shall not exceed 10 gallons.

c. Filling shall be by continuous piping from the storage tank or in small plants by piping from a filling inlet outside the room.

d. Shall be constructed in accordance with Class D, Containers for Hazardous Liquids, except that gravity flow may be permitted through continuous piping to the apparatus supplied.

e. Shall be provided with an ample overflow pipe connected to the main tank; if of the pressure type, this connection shall be from an approved pressure relief valve, set at not in excess of twice the normal working pressure.

f. Except in fireproof rooms (see "a" above) or by special permission of the inspection department having jurisdiction, provision shall be made so that the oil will automatically drain back to the supply tank upon shutting down the appliance served, leaving not more than one gallon for priming, or in pressure systems that the pressure will be automatically released.

IGNITION AND STARTING.—(a) Torches for pre-heating the combustion chamber of engines are to be used only while starting the engine, and the pressure on the supply reservoir is to be released as soon as the engine is "firing" properly.

(b) Torches used for initially heating the combustion chamber must be of a type approved for use with kerosene.

(c) Gasoline if used for starting must be introduced as a fuel within the cylinders of the engine and the supply of gasoline must not be more than necessary to produce a proper temperature for operating the engine with the heavier oils.

(d) The gasoline supply for engines using this liquid for starting must be drawn from an outside underground storage tank by means of a hand pump permanently attached to the engine, into an approved feed cup having a capacity of not more than one pint and provided with an overflow to the outside gasoline tank, or an approved reservoir of the "lift out" type may be used provided the capacity is limited as in Rule 36c, but not to exceed one gallon, and further that the retention of any gasoline after starting is automatically prevented.

EXHAUST PIPE.—Water pockets in exhaust pipes to be provided with suitable means for drainage.

EDITOR'S NOTE.—The above regulations are to lessen the hazard, and are not based on the relative reliability of the machine for operation purposes; for use where great reliability is necessary, as in water-works plants, additional requirements are necessary, covering the ability to start quickly and operate continuously under varying load.

INDIVIDUAL OIL BURNING EQUIPMENTS FOR OTHER THAN HOUSEHOLD PURPOSES*

Apparatus using oil for fuel, however safeguarded, introduces a distinct increase in hazard which should be recognized.

Where used, the following rules should be rigidly observed.

All oil used for fuel purposes under these rules shall show a flash test of not less than 150 degrees Fahrenheit. (Abel-Pensky Flash Point Tester.) This flash point corresponds closely to 160 degrees F. (Tagliabue Open Cup Tester), which may be used for rough estimations of the flash point.

EDITOR'S NOTE.—In the regulations for Fuel Oil Engines (see page 161) as revised in 1915, the National Board of Fire Underwriters adopted 100 degrees Fahr. as the minimum allowed for fuel oil. At the meeting of the National Fire Protection Association in May, 1916, it was recommended that the regulations for Fuel Oil Equipment be changed accordingly; final action has not been taken by the National Board of Fire Underwriters.

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*Abstracted from regulations of National Board of Fire Underwriters.

CAPACITY AND LOCATION OF TANKS.—a. In closely built up districts or within fire limits tanks to be located underground and tanks and piping are to be as given in the requirements on pages 139 and 144.

Outside of closely built up districts or outside of fire limits, above-ground storage tanks may be permitted, provided drainage away from burnable property in case of breakage of tanks is arranged for or suitable dikes built around the tanks.

When above-ground tanks are used all piping must be arranged so that in case of breakage of piping the oil will not be drained from tanks. This requirement prohibits the use of gravity feed from storage tanks. Above-ground tanks of less than 1,000 gallons capacity without dikes may be permitted in case suitable housings for the protection of the tanks against injury are provided.

Some device for indicating the level of the oil in the tank is desirable. Where used, such attachment shall be connected through substantial fittings so as to minimize exposure of the oil, and devices the breakage of which will allow the escape of oil, must not be used.

Suitable filters or strainers for the oil should be installed and preferably be located in supply line before reaching pump. Filter to be arranged so as to be readily accessible for cleaning.

Feed Pumps must be of approved design, secure against leaks.

EDITOR'S NOTE.—At a meeting of the National Fire Protection Association in May, 1916, the requirement for Pumps was recommended to be changed as given below; action by the National Board of Fire Underwriters had not been taken at the time this book went to press:

Pressure Delivery Systems.—a. Delivery from tank to burners may be direct or through receivers, accumulators or stand-pipe.

b. Must be by a substantially constructed discharge device of approved design, which will prevent the delivery or leakage of liquid when not in use.

c. Must be provided with safety reliefs, which will prevent the accumulation of pressure in excess of twice the normal working pressure; such reliefs to be of a design which will not discharge inflammable liquid into the open air.

d. Must be of a design that when delivering to a system of several individual oil burning equipments, pressure will be maintained on the piping inside the building only when the equipment is in actual use. Or shall be so equipped that a flow in excess of the normal discharge of any individual oil burning equipment will result in automatically shutting off the power producing the pressure or cutting off supply to the piping within the building supplying that equipment.

Glass gauges, the breakage of which would allow the escape of oil, are to be avoided. If their use is necessary, they should have substantial protection or be arranged so that oil will not escape if broken. Pet cocks must not be used on oil carrying parts of system.

Readily accessible shut-off valves to be provided in the supply line as near to the tank as practicable, and additional shut-offs to be installed in the main line inside building and at each oil consuming device.

Receivers or Accumulators, if used, must be designed so as to secure a factor of safety of not less than 6. Must be subjected to a pressure test of not less than twice the working pressure. The capacity of the oil chamber must not exceed 10 gallons. To be equipped with pressure gauge. To be provided with an automatic relief valve set to operate at a safe pressure and connected by an overflow pipe to supply tank, and so arranged that the oil will automatically drain back to the supply tank immediately on closing down the pump.

Standpipes, if used, shall not exceed 10 gallons capacity. To be of substantial construction, equipped with an overflow, and so arranged that the oil will automatically drain back to the supply tank on shutting down pump, leaving not over one gallon, where necessary, for priming, etc. If vented, the opening should be at the top and may be connected with the outside vent pipe from storage tank, above level of source of supply.

Editor's Note.—At a meeting of the National Fire Protection Association in May, 1916, the above section on Auxiliary Tanks was recommended to be changed as given below; action by the National Board of Fire Underwriters had not been taken at the time this book went to press:

Auxiliary Tanks, Standpipes, Receivers or Accumulators.—

a. These may have a total capacity of 60 gallons, and may be of an individual capacity not exceeding 60 gallons, if the containing room is fireproof, not used for other manufacturing or storage purposes and provided with standard wall opening protection on all interior and exterior walls.

b. In room other than described above, the capacity shall not exceed 10 gallons.

c. Filling shall be by continuous piping from the storage tank or in small plants by piping from a filling inlet outside the room.

d. Shall be constructed in accordance with Class D, Containers for Hazardous Liquids, except that gravity flow may be permitted through continuous piping to the apparatus supplied.

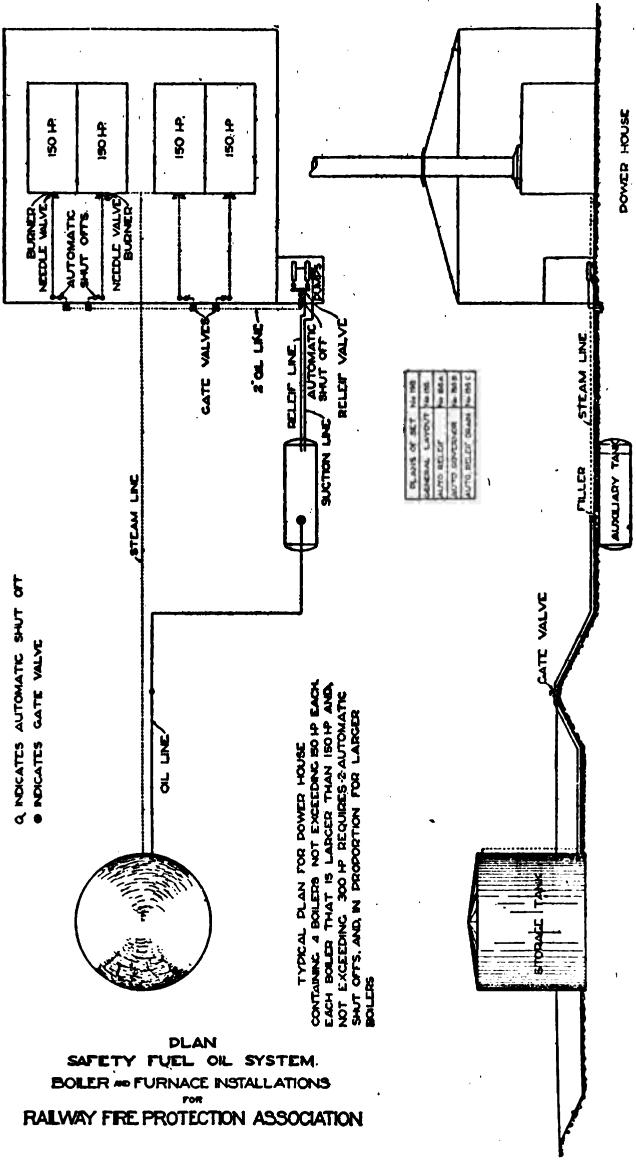
e. Shall be provided with an ample overflow pipe connected to the main tank; if of the pressure type, this connection shall be from an approved pressure relief valve, set at not in excess of twice the normal working pressure.

f. Except in fireproof rooms (see "a" above) or by special permission of the inspection department having jurisdiction, provision shall be made so that the oil will automatically drain back to the supply tank upon shutting down the appliance served, leaving not more than one gallon for priming, or in pressure systems that the pressure will be automatically released.

A committee of the Railway Fire Protection Association, in a report made at the annual meeting in October, 1915, gave, in addition to the National Board regulations above, which they adopted, the following requirements:

Gravity Systems should not be installed under any conditions, as they are a menace to both life and property.

Pumping Systems.—Plate No. 1 shows the plan of a large storage tank with auxiliary tank and pumping system, also the pump lines; and how this system should be installed to give the proper protection and service where large equipments are used.



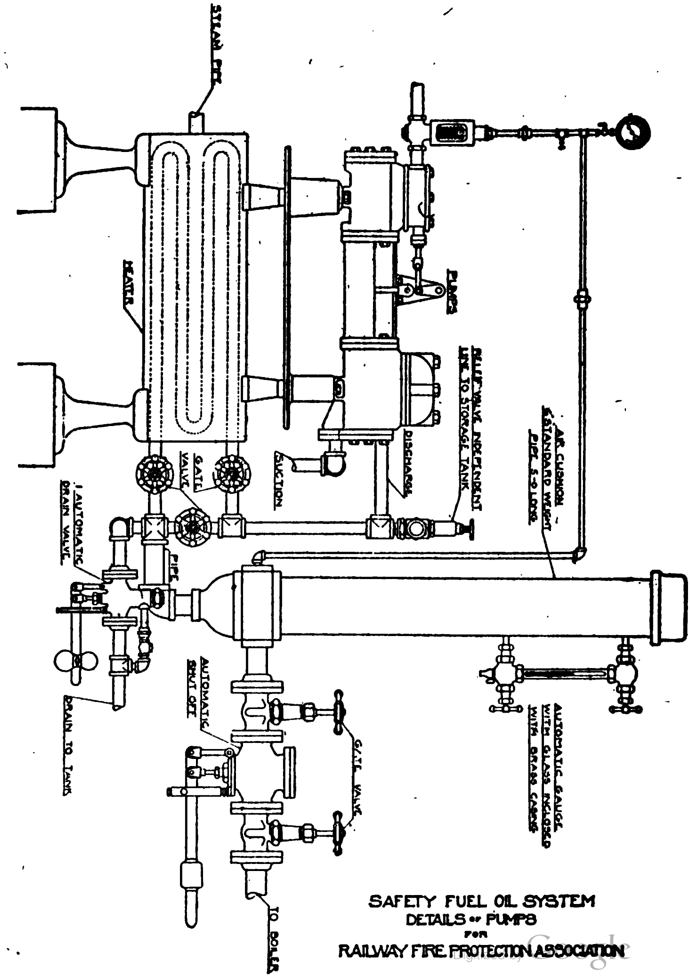
TYPICAL PLAN FOR POWER HOUSE CONTAINING 4 BOILERS NOT EXCEEDING 150 H.P. EACH. EACH BOILER THAT IS LARGER THAN 150 H.P. AND NOT EXCEEDING 300 H.P. REQUIRES 2 AUTOMATIC SHUT OFFS, AND, IN PROPORTION FOR LARGER BOILERS

PLAN
SAFETY FUEL OIL SYSTEM.
BOILER AND FURNACE INSTALLATIONS
FOR
RAILWAY FIRE PROTECTION ASSOCIATION

PLATE No. 1

This equipment will apply to large furnace installations as well as to boiler plants.

Plate No. 2 shows the detail of a steam pump equipment and how it should be arranged to obtain the best service and protection. This arrangement will also apply to rotary pumps with the exception of the steam governor. The order of the automatic appliances should be strictly adhered to. The steam governor, controlling the pump direct from the cushion, should be set at a pressure 25 per cent lower than the relief valve, so that the oil will not be circulated through the relief valve unless the steam governor should become inoperative. By placing the relief valve at this point, only cold oil is handled by the pump or discharged back into the tank.


STEAM PIPE
HEATER
PUMPS
RELIEF VALVE INDEPENDENT LINE TO STORAGE TANK
AIR CUSHION & STANDARD WEIGHT PIPE 5-0 LONG
DISCHARGE
SUCTION
GATE VALVE
1 AUTOMATIC DRAIN VALVE
PIPE
DRAIN TO TANK
AUTOMATIC SHUT OFF
GATE VALVE
TO BOILER
AUTOMATIC GAUGE WITH GLASS INCLOSED WITH BRASS CASING

SAFETY FUEL OIL SYSTEM
DETAILS OF PUMPS
FOR
RAILWAY FIRE PROTECTION ASSOCIATION

PLATE No. 2

The heater should be by-passed, so that in warm weather it will not be under constant pressure.

The automatic drain valve is placed at the lowest point of the line, so that absolute drainage can be secured.

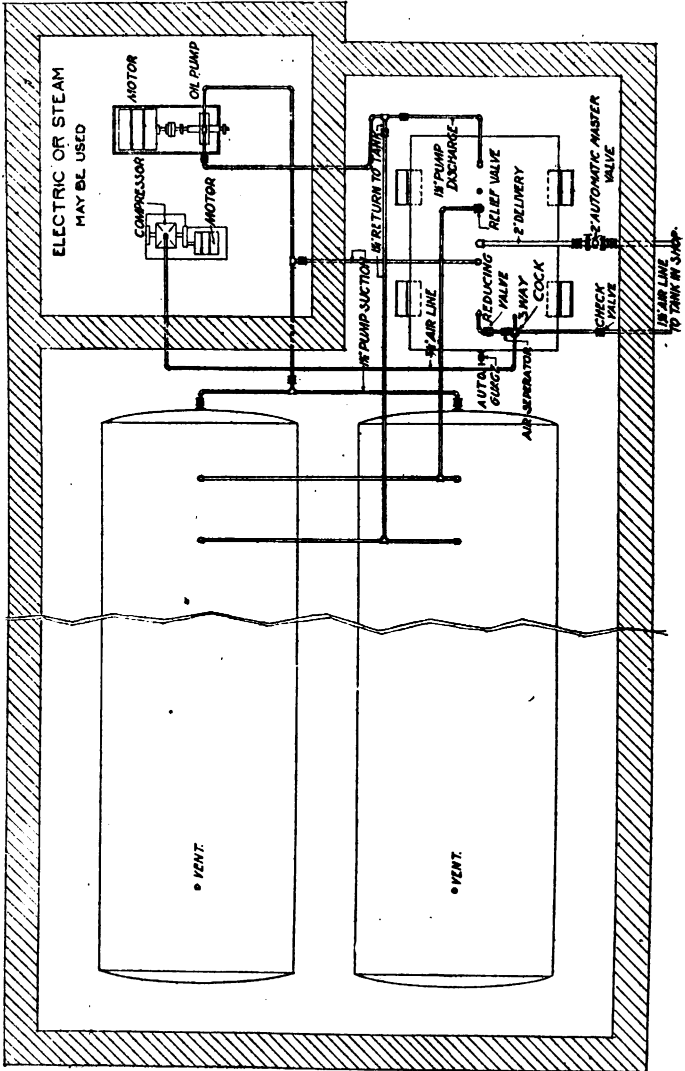


PLATE No. 3

The discharge of the pump into the air receiver is at right angles to the boiler or furnace supply. This is done to prevent throbbing and to maintain uniform pressure on the line.

The gauge glass on the receiver should be protected by automatic shut-off cocks in case of the glass breaking, and further it should be protected by double brass casings in case the automatic cocks should fail to operate.

The automatic stop valve is then placed in the direct line to the boiler or furnaces and is controlled by a gate valve before and after, so that the former can be opened and cleaned in case of necessity without spilling oil on the floor or emptying the fuel oil line.

Strainers should not be used anywhere in the lines, as they become clogged and are a constant source of menace. No dirt will ever enter the lines if the trouble is cured at the source. Large basket strainers placed in the manhole or the receiving line of the fuel oil storage tank will remove dirt and foreign

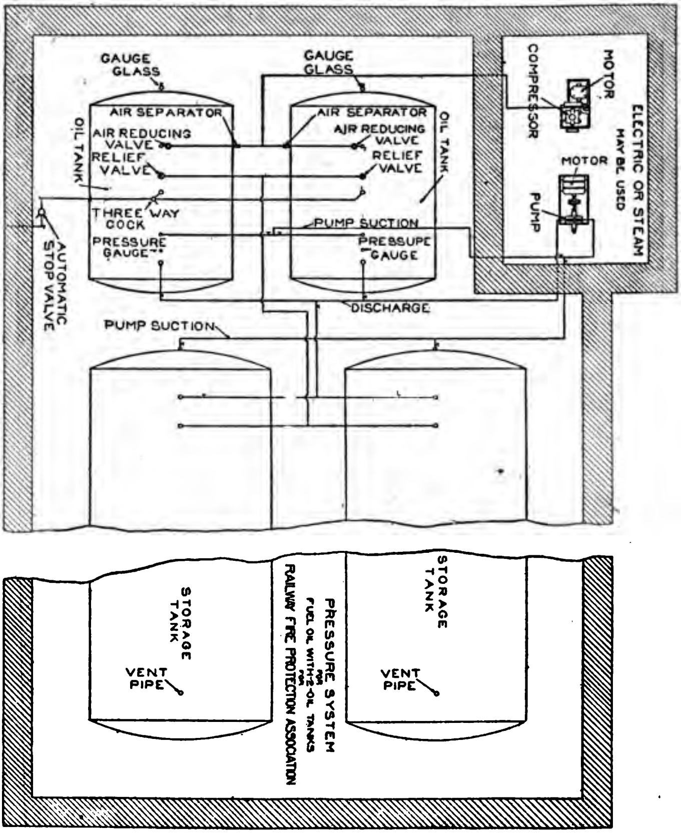


PLATE No. 4

matter before it gets into the system and better satisfaction will be obtained in the operation of the system and at less cost.

AIR PRESSURE SYSTEMS.—Plates Nos. 3 and 4 show two types of Air Pressure Systems, one with single tanks and the other with double tanks. While this system is not approved by the National Board of Fire Underwriters, it is undoubtedly the best system from the point of service obtained in the use of oil around the furnace. A steadier pressure is maintained upon the oil which reduces to a minimum the necessity for regulation of the furnace burners; there is under pressure a comparatively small amount of oil (not over a day's capacity for the shops) and but little time is required each day to fill the tanks for the day's run (the air maintaining a constant pressure).

The two plates mentioned show the storage and pressure tanks. The system having two pressure tanks is to be used when a day's supply would exceed a thousand gallons and the piping is so arranged that only one tank at a time is under pressure feeding the system. This is accomplished by a three-way valve which will permit the operation of only one tank at a time.

The other system is designed for a single pressure tank, which can be filled during working hours should the oil run low. The piping therefore is so arranged that if the pump should accidentally be allowed to run, the overflow of the tank will be discharged back into the main supply tank.

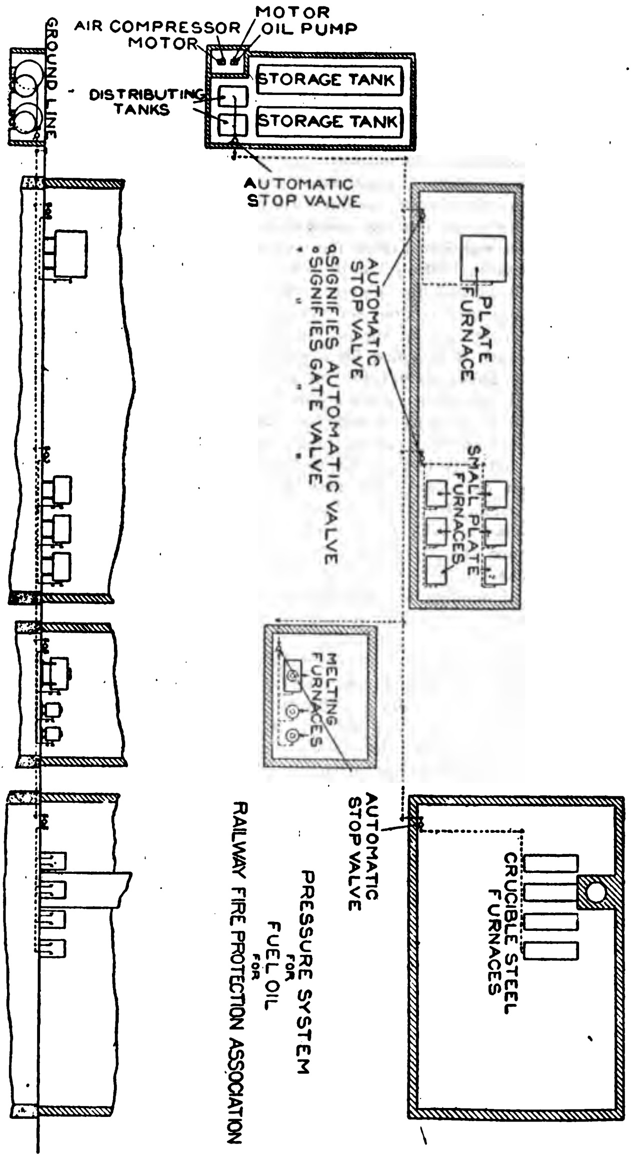
In many instances these supply tanks are filled by gravity from the main storage tanks, but this has proved unsatisfactory. If the connection is permanent between the main tanks and the pressure tanks, and the latter are not properly vented, the supply of oil in the storage tanks as well as that in the pressure tanks is liable to be discharged into the buildings. It is recommended, therefore, that no direct connection be made between these tanks and the storage tanks.

Plate No. 5 shows how the pipe lines should be run in a large plant. This applies not only to a pressure system, but also to a pumping system of any kind.

All lines drain back to the source of supply. They are outside the building as far as possible and all piping is underground, except the short pipe leading from the ground line to furnace. This should be adhered to as far as possible.

Plate No. 6 shows how the lines should be run in the buildings and to the furnaces in order to obtain the maximum protection. This method of protection prevents the operator at a furnace from drawing more oil than the furnace can properly consume; protecting therefore both operator and building. The method of testing the automatic stop valve as shown on this plate is for both the master valve and the group control valve.

All underground lines in the building should be at least 1 inch in diameter. The pipes leading from the underground lines to above the floor line should be at least ¾ inch in diameter and reduced by special reducing fittings and extra heavy angle valves, to which the automatic valves should be fastened. From there to the furnace the lines should be at least ½ inch. This gives stability and strength to the installation, and insures against breakage of pip-



PRESSURE SYSTEM FOR FUEL OIL FOR RAILWAY FIRE PROTECTION ASSOCIATION

No. 233

PLATE No. 5

METHOD OF INSTALLING AND TESTING
AUTOMATIC STOP VALVES
FOR
FUEL OIL SYSTEM
FOR
RAILWAY FIRE PROTECTION ASSOCIATION

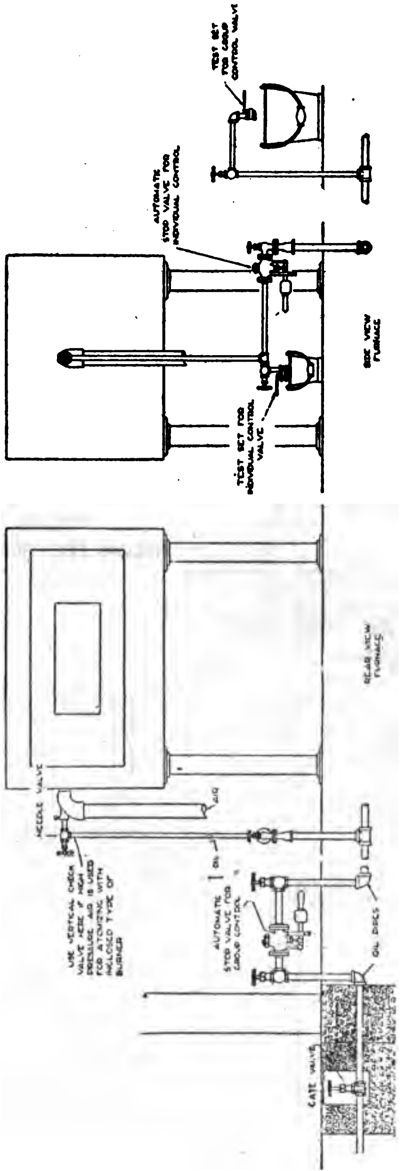

TEST SET FOR GROUP CONTROL VALVE
AUTOMATIC STOP VALVE FOR INDIVIDUAL CONTROL
TEST SET FOR INDIVIDUAL CONTROL VALVE
SIDE VIEW FURNACE
REAR VIEW FURNACE
NEEDLE VALVE
AIR
OIL
USE VERTICAL CHECK VALVE HERE IF HIGH PRESSURE AIR IS USED FOR ATOMIZING WITH INCLOSED TYPE OF BURNER
AUTOMATIC STOP VALVE FOR GROUP CONTROL
OIL PIPES
GATE VALVE

PLATE No. 6

ing which would stop temporarily the operation of the plant. On account of the small amount of piping required this heavier type of construction will amply repay for the expenditure, and the extra cost would not be 5 per cent on the installation.

There should be no connection anywhere in the building by which oil can be drawn from the fuel oil lines for lighting or other purposes. Such connections are rarely free from leak and eventually the ground becomes saturated with oil, which is liable to result in a serious fire.

If it is necessary to have a connection for filling portable tanks or for similar purposes, this should be done by a connection close to the pumps or an individual hand pump connected to the storage tanks.

RIVET OR PORTABLE FORGE.—Plate No. 7 shows a rivet forge which is properly protected and which should prevent accident in case of ruptured lines or overfeeding of the furnace. Whether the tank be set vertically or horizontally, the same method would be applied; but if a horizontal tank be used, the method shown on Plate No. 8, as far as it applies to this tank or furnace, is recommended.

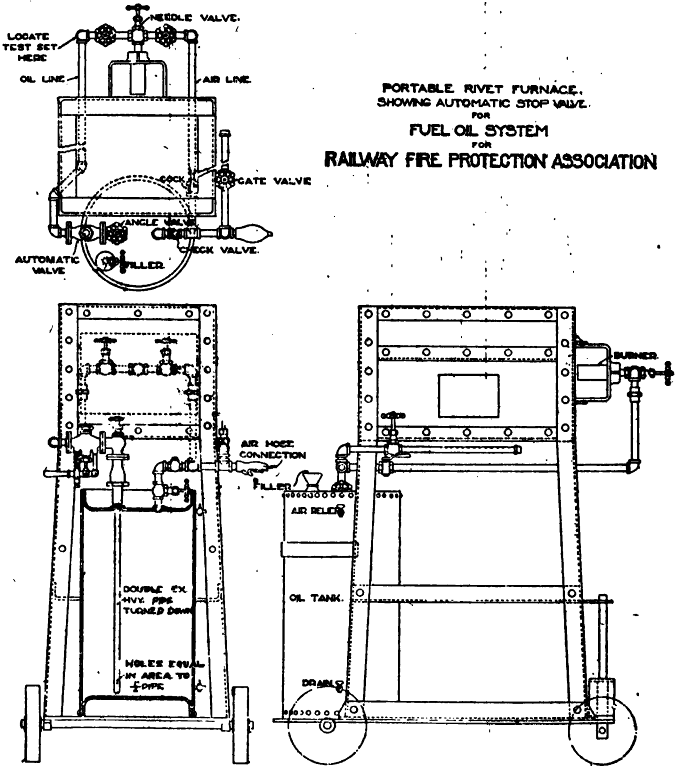


PLATE No. 7

PORTABLE WELDING TORCHES.—Plates Nos. 8 and 9 show a safe type of torch that can be cheaply constructed, and will immediately stop the discharge of oil in case of fracture in pipe or hose lines.

Torches using single hose lines (where the mixing is done close to the tank) should not be used, for the reason that the operator has no control of the oil in the hose line, and if the needle valve be leaky and the air turned on, the oil in the hose pipe line will be immediately discharged. This is liable to cause a serious fire or personal accident.

Plans of the proper burners to use in connection with the double hose line for the burning of fuel oil will be supplied upon application to the committee.

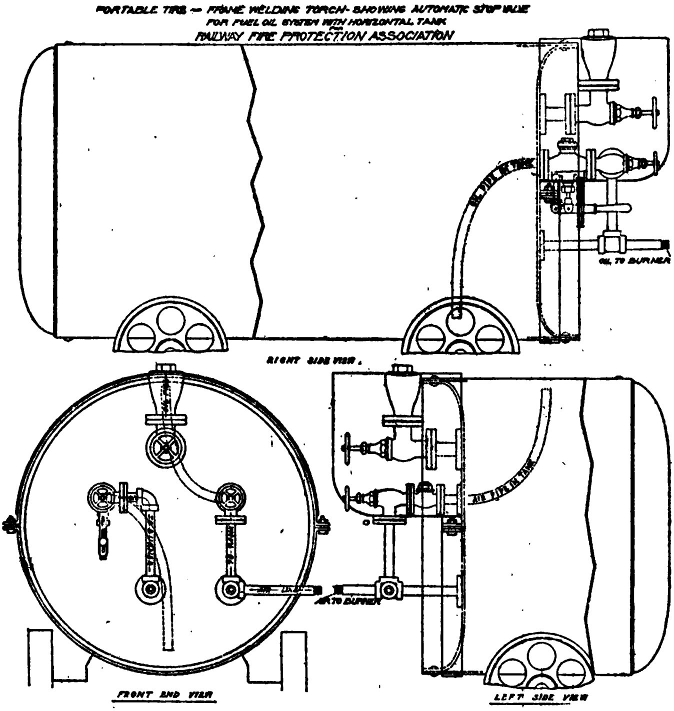

PORTABLE TIRE — FRAME WELDING TORCH - SHOWING AUTOMATIC STOP VALVE
FOR FUEL OIL SYSTEM WITH HORIZONTAL TANK
RAILWAY FIRE PROTECTION ASSOCIATION
OIL PIPE TO TANK
OIL TO BURNER
RIGHT SIDE VIEW
AIR PIPE IN TANK
AIR TO BURNER
FRONT END VIEW
LEFT SIDE VIEW

PLATE No. 8

In the discussion the following points were brought out:

Hose should not be used if it is possible to use metal piping for any connections on oil tanks or oil burning equipment. Metal hoods, of ample proportions and properly vented through the roof, should be provided over furnaces where necessary or where there is danger from a flash, or flare. Furnaces, wherever possible, should be located in non-combustible buildings, must be on non-combustible floors and a safe distance away from inflammable building construction or other material; wooden columns or windows, if necessary, to be covered or shielded with metal.

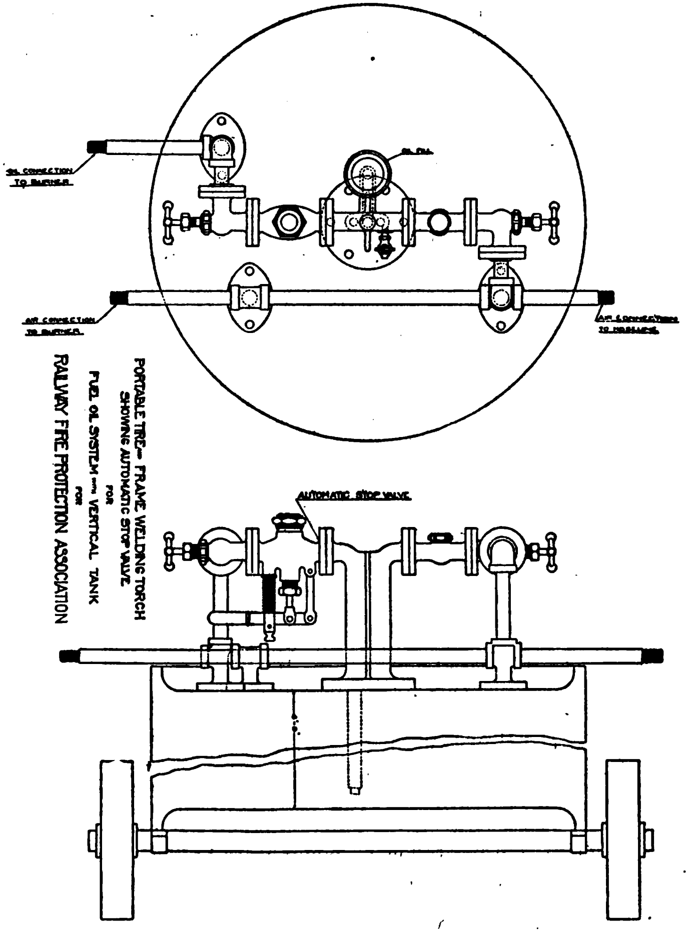

OIL CONNECTION TO BURNER
OIL FILL
AIR CONNECTION TO BURNER
AIR CONNECTION
PORTABLE TIRE — FRAME WELDING TORCH
SHOWING AUTOMATIC STOP VALVE
FOR
FUEL OIL SYSTEM — VERTICAL TANK
FOR
RAILWAY FIRE PROTECTION ASSOCIATION
AUTOMATIC STOP VALVE

PLATE No. 9

OIL CONVEYOR OR CARRIERS*

STEAMERS, ETC.—a. Steamers, barges or vessels loading or discharging oil in bulk, shall not load or discharge at wharves other than those used by the oil company, and such wharves shall be well isolated from all burnable property or wharfage.

b. There shall be a gate valve immediately at the point in the pipe line where connection is made with the hose leading to the ship for the purpose of shutting off the oil, and there shall be another gate valve in this line of pipe at a distance of at least 10 feet back from the wharf, where it will be readily accessible for the purpose of shutting the oil off in event of failure on the part of the valve first mentioned.

c. A tight connection shall be made with the hose length at the wharf by means of a carefully threaded coupling, to prevent leakage and accumulation of oil around the piers.

d. Lights. No fire nor open lights to be allowed on the vessel while at the wharf.

FUEL OIL APPARATUS FOR COOKING AND HEATING FOR HOUSEHOLD USE*

The use of oil as fuel for domestic purposes is regarded from the insurance viewpoint as more hazardous than the use of ordinary fuel, such as coal, wood and coke.

Where these systems are used their hazards should be recognized and the following rules and precautions should be observed. All oil used for fuel under these rules shall show a flash test of not less than 100° Fahr. (Abel-Pensky Flash Point Tester.) This flash point corresponds closely to 106° Fahr. (Tagliabue Open Cup Tester), which may be used for rough estimations of the flash point.

For Capacity, Location, Material and Construction of Tanks and of Piping, see pages 139 to 145.

PUMP.—Oil pump used in filling auxiliary tank from the main supply tank to be approved type, secure against leaks, with check valves located as close to the pump as convenient. Pumps should be rigidly fastened in place.

NOTE.—Stuffing box, if used, should be provided with a removable cupped gland designed to compress the packing against the shaft and arranged so as to facilitate removal. Packing affected by the oil must not be used.

AUXILIARY SUPPLY TANK.—a. If used, shall not exceed five gallons in capacity, except by special consent of the Inspection Department having jurisdiction.

b. Shall be located at least 10 feet, measured horizontally, from the burners.

c. Shall be provided with an overflow connection draining to the supply tank and a vent pipe leading outside the building, the latter to have a weatherproof hood. To be constructed of brass, copper or galvanized plate not less than 0.050″ (No. 18 U. S. standard gauge) in thickness. Joints to be made as specified for outside storage tanks.

VALVES.—a. Readily accessible valves to be provided near each burner and also close to the auxiliary tank in the pipe leading to burners.

b. Controlling valves to be constructed as specified in Rule 21b.

INSTALLATION OF BURNERS.—a. Overflow.—Burners shall be installed with overflow attachment so arranged that any surplus oil will drain by gravity from the burner through a pipe into a substantially constructed reservoir having a capacity of not less than that of the auxiliary tank.

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* Regulations of the National Board of Fire Underwriters.

Each tank to be constructed and vented as provided for auxiliary tanks.

b. Draughts.—No dampers to be used in smoke pipe between burner and chimney. Any regulation of draught which is necessary is to be accomplished through the dampers in front.

CONSTRUCTION OF BURNERS.—a. The size of the orifice through which the oil is supplied to the burners should be limited to furnish only sufficient oil for the maximum burning conditions when the controlling valves are wide open.

b. Valves to be arranged so as not to enlarge the orifice.

c. Burners containing chambers which allow the dangerous accumulation of gases are prohibited.

d. Burners containing oil conveying pipes or parts subject to intense heat or subject to stoppage from carbonization are prohibited.

e. Burners should be designed so that they can be easily cleaned, and so as not to allow leakage of oil.

INSTRUCTION CARD.—A card giving complete instructions in regard to the care and operation of the system to be permanently placed near the apparatus.

SAFETY CANS

For Open Stock of Liquids which at Ordinary Temperatures Give Off Inflammable Vapors*

MATERIAL.—(a) Weight. Cans one gallon and smaller must be constructed of tinned or leaded iron or steel sheets or sheet brass at least .0125-inch thick (IC = 108 pounds tin plate) or of galvanized sheet iron or copper at least .0156-inch thick (28 gauge galvanized iron, U. S. Standard).

Cans larger than one gallon must be constructed of tinned or leaded iron or steel sheets or sheet brass at least .0156-inch thick (IX = 126 pounds tin plate) or of galvanized sheet iron or copper at least .0187-inch thick (26 gauge galvanized iron, U. S. Standard).

(b) Quality. All materials must be annealed to allow working without cracking the seams.

(c) Coating. Tinned steel sheets must carry a coating of at least two pounds per 100 square feet (Charcoal grade), leaded steel sheets at least three and one-half pounds per 100 square feet, galvanized sheet iron at least nine pounds per 100 square feet. Electroplating with copper, nickel or other material equivalent to the tin coating above specified will be acceptable.

SEAMS.—Cans, one quart and larger, must be made with straight seams of body grooved or riveted; ends double seamed, machine crimped, riveted or otherwise secured to body, so body parts will remain together after solder is melted. All seams must be soldered tight or brazed.

CLOSURES.—(a) Each opening into the can body must have an automatic valve, which will remain securely closed with the can in all positions, until it is opened by the application of manual pressure at a specific point in a definite direction (a series of small holes, controlled by a single valve, is considered a single opening). Provided, however, that a can having a capacity of one quart or over may be provided with a screw cap closure to the filling opening if the cap is lined with flexible oil-proof material and is chained to the can with safety chain, permanently secured.

(b) Cans one quart and larger, must be provided with a valve or equivalent device, so constructed that pressure of vapor from within will open it and relieve the pressure before it accumulates an amount sufficient to rupture any seam of the can.

(c) Cans, smaller than one quart, shall be limited to a single valved opening into the body of the can adapted to both filling and emptying.

(d) Cans having closures which permit a leakage of more than four drops per minute, must be condemned.

NOTE.—60 drops = 1 teaspoonful per hour; 438 drops = 1 fluid ounce; or, 1 pint in 112 hours.

(e) No can shall have more than two valved closures, and where two are used, each valve must be closed independently to avoid leaks resulting from unequal wear of valves or from lost motion.

PROHIBITIONS.—Openings into the body of the can provided with stuffing boxes, removable plugs or corks, also bearing pins smaller in diameter than 3/32-inch (No. 13 U. S. Standard) are prohibited.

PROPORTIONS.—To insure reasonable stability, it is desirable that the height of the body does not exceed the diameter more than fifteen per cent.

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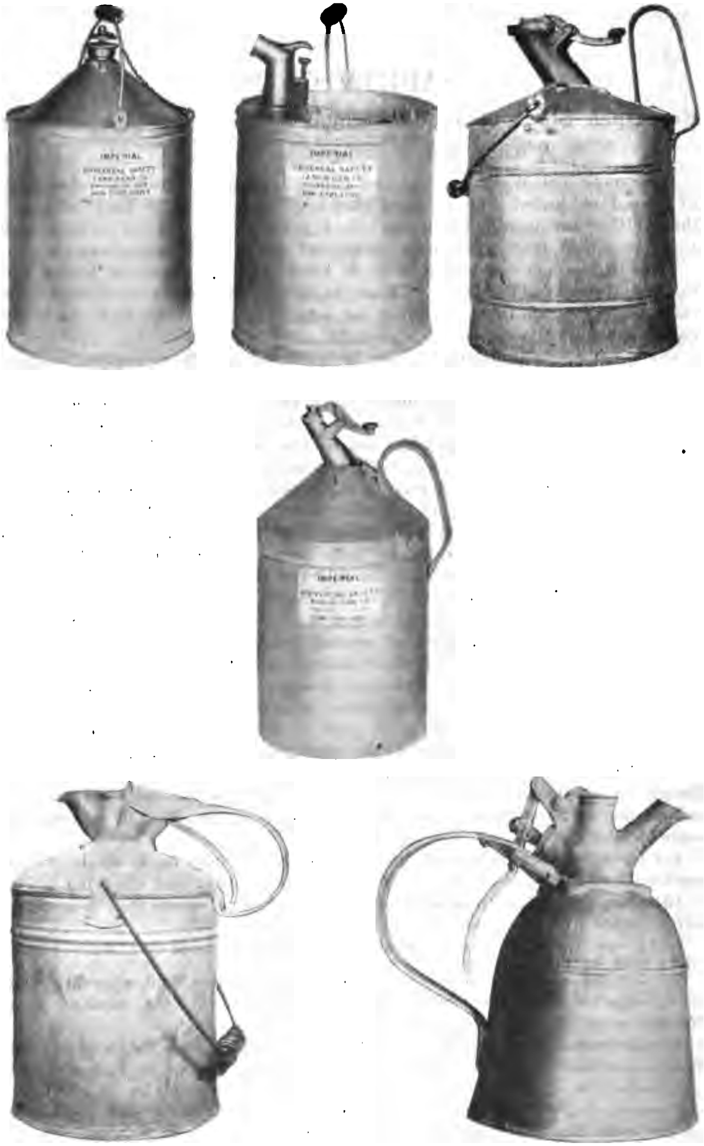
* As recommended by the National Board of Fire Underwriters.



Safety Cans for Hazardous Liquids.

OIL LIGHTING SYSTEM

Extensive use has been made of gasoline to furnish light, particularly before the large field for the use of gasoline for automobiles made such gasoline systems relatively of less importance to the oil producers. The rapid improvement in the electrical art, and the big cuts made in the cost of producing electricity, have also tended to reduce the use of oil lighting systems. The National Board of Fire Underwriters have issued rules covering both Kerosene Pressure systems and Gasoline Lighting systems, but as these are mainly details of construction of the apparatus, they are not given herein. Several different makes of each kind are listed by the Underwriters' Laboratories as being safeguarded insofar as the hazard permits; the use of only such as are listed is strongly urged, as improperly constructed appliances are a distinct hazard.

Of the Gasoline Systems, five classes are listed, divided as follows:

Class A—Machines Having Outside Carbureters

These machines, which do not introduce liquid gasoline into the building, are regarded from an insurance viewpoint as constituting the least dangerous type of gasoline gas machine.

To be located outside the building, underground, at least 30 feet removed from all buildings, and the top thereof must be below the level of the lowest pipe in the building used in connection with the apparatus.

Class B—Machines Having Inside Carbureters

These machines are regarded from an insurance viewpoint as more dangerous than those having outside carbureters, owing to the fact that they introduce gasoline in liquid form and manufacture gas inside the building. Where permitted the following rules and precautions should be rigidly observed:

Supply tank must be located outside the building, underground where possible, and below the level of the lowest pipe in the building used in connection with the apparatus.

If impracticable to bury the supply tank the same may be installed in a non-combustible building or vault properly ventilated, preferably from the bottom, always remembering that it must be below the level of the lowest pipe in the building used in connection with the apparatus.

Class C—Gasoline Lighting Systems Having Outside Tanks and Inside Flame Heated Generators

These systems are regarded from an insurance viewpoint as more dangerous than the systems in Class A or Class B. Where used their hazards should be recognized by Underwriters and the following rules and precautions should be rigidly observed:

Supply tank must be limited to 6 gallons.

To be located outside the building and so arranged that under normal conditions the only gasoline in the building will be that contained in the hollow wires leading to lamps or to the common generator.

Class D—Gasoline Vapor Lamps

These lamps are regarded from an insurance viewpoint as even more dangerous than the systems covered in Class A, Class B or Class C, and where used their hazards should be recognized. If permitted, the general specifications for the construction of such devices and for regulating same should be observed.

Class E—Systems Having Inside Tanks and Inside Flame Heated Generators

These systems which embody the hazard of handling gasoline inside buildings are regarded from an insurance viewpoint as more dangerous than the devices covered in Class A, Class B or Class C, and on a par with those of Class D. When used their hazards should be recognized.

If permitted, the following general specifications for the construction of such devices and for regulating same should be observed.

Supply tank not to exceed 6 gallons.

Should preferably be located against an outside wall and so installed that a clear space is maintained above and below from floor to ceiling, and for at least a foot on either side of the device.

NOTE.—Where located against other than a fireproof wall to be insulated therefrom by an ample sheet of metal placed not less than 1 inch from the wall, leaving an air space.

GASES AND VAPORS

Gas Defined.—In a restricted sense the name gas is applied to bodies that exist in the gaseous state at the ordinary temperature and pressure, and can only be liquefied or solidified by artificial means. Vapors are the gases given off, with or without the aid of heat, by bodies that, under ordinary circumstances are either solid or liquid.

When several gases or vapors are present they mix with comparative rapidity; only very dense vapors and very light gases remaining unmixed for any length of time.

Under ordinary circumstances, and when in a pure state, gases and vapors are non-explosive, even though combustible.

Gas Explosion.—Explosions of gas or vapor sometimes occur in places where, though there is explosive mixture, there is neither fire, light, nor other burning substances; this is due to the *migration* of the gas or vapor caused by its relatively higher or lower density than air. Such instances of fire or explosion are said to be produced by remote fire, or flashing back, and may be produced by contact with a lighted stove, a lamp, a discarded lighted or burning match, or the like.

Explosion Temperatures.—Gases and vapors may be ignited or exploded by heat as well as by flame. A list of these explosion temperatures is given below:

	Degrees C.		Degrees C.
Oxyhydrogen gas	620–700	Carbon disulphide vapor	100–170
Under pressure	518–606	Acetylene	509–515
Carbon monoxide	636–814	Propane	545–548
Methane	656–678	Propylene	497–511
Ethane	605–622	Coal gas	647–649
Ethylene	577–599	Hydrogen	555

Limits of Explosibility.—According to Professor Bunte of Carlsruhe, the limits of explosibility can be greatly varied by circumstances, such as the lateral dimensions of the containing vessel, the method of ignition, volume of gas present, moisture content of same, etc. The same authority gives the following values in the case of electrical ignition, the mixtures of air with the several gases mentioned exploding when the proportion of gas attains the following percentages:

	Per Cent	Range of Explosibility
Carbon monoxide	16.6–74.8	58.2
Hydrogen	9.5–66.5	57.0
Water gas	12.5–66.6	54.1
Acetylene	3.2–52.2	49.0
Coal gas	8.0–19.0	11.0
Ethylene	4.2–14.5	10.3
Alcohol vapor	4.0–13.6	9.6
Methane	6.2–12.7	6.5
Ether vapor	2.9– 7.5	4.6
Benzol vapor	2.7– 6.3	3.6
Pentane	2.5– 4.8	2.3
Benzine vapor	2.5– 4.8	2.3

According to Dr. Von Schwartz, the range of explosibility in an admittedly very imperfect series of gases and vapors is as given below, the figures in the first column representing the minimum percentage of gas, and those in the second the maximum percentage, at which an explosion of the mixture is possible. The gases are arranged in reverse order, starting with the one exhibiting the highest minimum; and the values cited are merely approximate, great divergence prevailing in the figures given by different authors.

	Percentage	Approximate Relative Range of Explosibility
Carbon monoxide	13–75	3
Carburetted air (air gas)	9–26	5
Water gas	9–55	4
Coal gas	8–23	6
Hydrogen	7–75	2
Carbon disulphide vapor, from 6 downwards		Merely approximate
Ether disulphide vapor, from 6 downwards		
Methane (marsh gas)	5–13.16	8
Ethylene	4–22	7
Acetylene	3–82	1
Benzol (Benzine), 2.6–4.8	3–6	9
Toluol	....	about 7
Pentane	2.5–5	10

Above and below these limits no explosion occurs, the mixture merely flashing at the upper limit. The explosion of the mixtures can be prevented by additions of 7½–10 per cent of carbon dioxide.

Ventilation.—To facilitate solution of the general problem respecting the comparative advantages of roof and floor ventilation, lists of the gases (g) and vapors (v) respectively lighter and heavier than air are given by Dr. Von Schwartz as follows, the density of air being taken as unity.

(1) Lighter than Air (Roof Ventilation)

0.069	Hydrogen (g)
0.400–0.600	Coal gas (g)
0.553	Pit gas (Firedamp) (g)
0.588	Ammonia (g)
0.622	Water vapor (v)
0.700	Wood gas (g)
0.898	Acetylene (g)
0.945	Hydrocyanic acid (g)
0.967	Ethylene (g)
0.967	Carbon monoxide (g)

Water gas, generator gas, Dowson gas, power gas, and similar gases differ considerably in density according to their composition, but are all lighter than air.

0.987–1.015	Mond gas (according to the coal used)
0.510	Water gas
0.830–1.000	Generator gas

(2) Heavier than Air (Floor Ventilation)

1.036	Ethane (g)
1.039	Nitric oxide (g)
1.105	Oxygen (g)
1.120	Methyl alcohol (v)
1.185	Phosphuretted hydrogen (g)
1.192	Sulphuretted hydrogen (g)
	Air gas (carburetted air) (v):—
1.260	With 10% of hydririne
1.275	With 11½% of hydririne
1.317	With 14% of hydririne
1.382	Allylene (g)
1.451	Propylene (g)
1.520	Propane (g)
1.527	Nitrous oxide (g)
1.530	Ethyl aldehyde (v)
1.590	Hyponitrous acid (g)
1.613	Alcohol (v)
1.617	Methyl ether (g)
1.738	Methyl chloride (g)
1.800	Cyanogen (g)
1.935	Butylene (g)
2.004	Butane (g)
2.104	Carbon oxysulphide (g)
2.200	Sulphur (v)
2.448	Chlorine (g)
2.565	Ether (v)
2.645	Carbon disulphide (v)
2.697	Arseniuretted hydrogen (v)
2.770	Benzol (v)
2.784	Seleniuretted hydrogen (g)
3.147	Amyl alcohol (v)
4.215	Chloroform (v)
4.355	Phosphorus (v)
4.498	Telluretted hydrogen (g)
5.700	Selenium (v)
6.650	Sulphur vapor
8.896	Tellurium (v)

Gas Containers.—According to Dr. Von Schwartz in *Fire and Explosive Risk,* the following points may be stated with reference to the fitting up of the gas cylinders and their pipe connections:

(1) Liquid gases should never be used or stored, not to say manufactured, in workrooms containing inflammable materials or explodible vessels.

(2) The cylinders and pipes may only be placed in suitable cool situations, shaded from the sun and remote from any source of heat (a stove or lamp).

(3) The waste gas that cannot be used again must not be allowed to escape in or towards any place where it might become ignited by sparks, fire, or incandescent material (flues). Exceptions to this rule are afforded by the uninflammable gases sulphuric acid, ammonia, and carbon dioxide; but oxygen, though itself uninflammable, may stimulate combustion in other burning materials, and should therefore be kept at a distance from fires of all kinds.

(4) The cylinders must fulfil legislative requirements, be officially certified and tested, mounted on secure foundations, provided with safety valves of sufficiently strong construction, and have been thoroughly annealed at the time of manufacture.

(5) If the outlet valve be opened very quickly, the temperature in the pressure regulator is raised to a point sufficient to carbonize wood shavings, i. e., 160°-200° C. This temperature has been observed in the case of carbon dioxide, which is harmless, so far as inflammability is concerned; and in the case of inflammable gases the very rapid opening of the valve would lead to considerable risk of explosion.

(6) Explosions of liquefied combustible gases may easily cause fires, whereas, in the case of incombustible gases, e. g., carbon dioxide, ammonia, sulphur dioxide, such a result can only occur when particularly inflammable materials, carriers of oxygen, or dust-yielding substances are present.

(7) With certain gases the escape from the cylinder is accompanied by electrical phenomena, which may prove a source of danger, especially in the case of readily inflammable gases.

(8) Cylinders containing liquid gases should never be heated to more than 30° C, and this temperature, which may readily be attained in the sun, may induce explosion even in the case of the best-made cylinders. Conveying gas cylinders on open wagons exposed to the heat of the sun, is a dangerous proceeding.

In the United States, the Interstate Commerce Commission has issued regulations covering the construction of cylinders and drums for compressed or liquefied gases or gases in solution. The provisions of these regulations have been adopted by the National Board of Fire Underwriters for storage containers for acetylene and like gases, and are in use by various cities. Containers meeting the above regulations are required to have stamped, labeled or marked thereon "Complies with the I. C. C. Spec'n No. —." These containers, if used for gases, must be tested every five years, and must not show a permanent expansion of over ten per cent.

These regulations provide that containers of inflammable liquids must not be entirely filled, a vacant space equal to two per cent being required.

ACETYLENE APPARATUS

Calcium carbide in its commercial form is harmless in so far as the effect of fire on it is concerned. With the application of water, however, it decomposes and generates acetylene; when left open its great affinity for water permits absorption of moisture from the air, with a gradual liberation of acetylene. Because of this, the commercial packages are made very tight; instances are known where large quantities have been sunk or flooded, with no harmful effect on the contents of the drums. In small quantities, if the containers are kept closed and above the floor, to prevent accidental letting in of water, there is little hazard, and storage is permitted in most any place. For larger storage, the rules of the National Board of Fire Underwriters are as follows:

> Calcium carbide in excess of 600 pounds shall be stored in approved metal packages above ground in one-story buildings without cellar or basement and used exclusively for the storage of calcium carbide. Such buildings shall be constructed to be dry, waterproof and well ventilated. Buildings shall be located outside congested mercantile or manufacturing districts. If storage building is of incombustible construction it may adjoin other one-story buildings if separated therefrom by an unpierced fire wall; if detached less than ten feet from such one-story buildings there shall be no openings in the adjacent sides of either building. If carbide storage building is of combustible construction it must not be within 20 feet of other one-story or two-story buildings, nor within 30 feet of other buildings over two stories.

Acetylene.—Pure gaseous acetylene under a pressure of less than 1 atmosphere may be exposed to powerful shocks, blows, falls from a considerable height, and the effects of gunshot, without exploding; but if there is any liquid acetylene in the vessel or any sparks are produced, there will be a violent explosion. However, as it is highly explosive at 2 atmospheres it is desirable not to store it under pressure.

Anything likely to produce sparks is a source of danger to acetylene kept under pressure. All vessels should be protected from the action of heat, since the gas should never be heated above 100° F., at which temperature the effects are the same as those of direct ignition, electric sparks, etc., and explosion may result even if the gas be under moderate pressure. An acetylene burner will reignite the gas if the tap is turned on again before it has cooled.

Through the sudden opening of the delivery apertures of vessels containing acetylene under pressure, the escaping gas may become so hot as to take fire. The overcharging of the vessels that are not sufficiently cooled, or the transfer of acetylene from a small vessel (under pressure) to a larger one, is also a source of danger.

To prevent acetylene lighting back from the burner jet to the generator, at least two non-return valves or back-flash preventors should be provided.

To diminish the dangers of acetylene it is sometimes mixed with coal gas or oil gas. The latter in particular is now used, in the proportions 50 per cent of acetylene and 50 per cent of oil gas, or 60-65 per cent of oil gas and 40-35 per cent of acetylene. In addition to being inexplosive, these mixtures may be subjected to a pressure of 6 atmospheres. Acetylene is not well suited for incandescent lighting, the mantles being rapidly injured and spoiled by the violence of the detonations on lighting the gas.

The dangers of acetylene have been reduced by dissolving the gas in liquids that are capable of absorbing it in large quantities. Water is unsuitable for this purpose, since it merely dissolves its own volume of the gas; and, besides, this solution is always dangerous when brought into contact with burning gases or oxygen. Hence all water containing acetylene, and especially waste waters that have stood in contact with the gas for some time, must be handled with care.

The best solvent is acetone. Under ordinary pressure, this liquid will take up 31 times its own volume of the gas; and if cold be employed, one part of acetone will absorb, at —81° C. (the solidification point of acetylene), as much as 2,000 parts of acetylene, its own volume being thereby increased 4 to 5 fold. Even under pressure alone—though this is dangerous—the solvent capacity can be raised to 50 volumes of acetylene to one of acetone. The solution may be exposed to a pressure of 10 atmospheres without any great danger being incurred. If the acetone is supersaturated with acetylene, or the solution is heated so that free gas accumulates in the container, this gas will present the same dangers as acetylene gas under pressure.

In using or generating acetylene, it is highly advisable to use only generators and appliances which have been listed by the Underwriters' Laboratories, which guarantees that the appliances have been examined under a rigid set of requirements tending largely to reduce the otherwise high hazard of this gas.

The insurance regulations, as given below, permit the location of stationary automatic generators inside the building being lighted. In the first rules adopted, the larger sizes were prohibited inside buildings, and were required to be in a special generator house 30 feet distant; because the hazard was primarily one of explosion and there was little *fire* hazard, these have been changed, against the judgment of many insurance engineers, who felt that the hazard to life was sufficiently great to still require the separate generator house. A form of generator becoming more common is the so-called "Pit Generator;" this is buried and is located at least 30 feet from any building. While not provided with all the safety features of the stationary automatic generator used inside a building, the damage possible with an explosion is greatly reduced; it is strongly recommended that this type be used where possible.

The installation rules of the various types of machines, as issued by the National Board of Fire Underwriters, are as follows:

(See also appendix for changes made in the Regulations in 1916 and Regulations for Classes D and C.)

The use of liquid acetylene or gas generated therefrom is absolutely prohibited.

Class A—Stationary Automatic Apparatus

1. FOUNDATIONS.—*a.* Where practicable to be of brick, stone, concrete or iron. If necessarily of wood they shall be extra heavy, located in a dry place and open to the circulation of air.

The ordinary board platform is not satisfactory. Wooden foundations shall be of heavy planking, joists or timbers, arranged so that the air will circulate around them and so as to form a firm base.

b. To be so arranged that the machine will be level and unequal strain will not be placed on the generator or connections.

2. LOCATION.—*a.* Generators, especially in closely built up districts, should preferably be placed outside of insured buildings in generator houses constructed and located in compliance with Rule 9.

b. Generators to be so placed that the operating mechanism will have room for free and full play and can be adjusted without artificial light. They must not be subject to interference by children or careless persons, and if for this purpose further enclosure is necessary it must be furnished by means of slatted partitions permitting the free circulation of air.

c. Generators which from their construction are rendered inoperative during the process of recharging to be so located that they can be recharged without the aid of artificial light.

d. Generators to be placed where water will not freeze.

3. ESCAPES OR RELIEF PIPES.—Each generator to be provided with an escape or relief pipe of ample size; no such pipe to be less than three-quarters inch internal diameter. This pipe to be substantially installed, without traps, and so that any condensation will drain back to the generator. It is to be carried to a suitable point outside the building, and terminate in an approved hood located at least twelve feet above ground and remote from windows.

The hood is to be constructed in such a manner that it cannot be obstructed by rain, snow, ice, insects or birds.

4. CAPACITY.—*a.* To be sufficient to furnish gas continuously for the maximum lighting period to all lights installed. A lighting period of at least 5 hours is to be provided for in every case.

b. Generators for conditions of service requiring lighting periods of more than 5 hours to be of sufficient capacity to avoid recharging at night.

The following ratings will usually be found advisable:

(1) For dwellings, and where machines are always used intermittently, the generator to have a rated capacity equal to the total number of burners installed.

(2) For stores, opera houses, theatres, day run factories, and similar service, the generator to have a rated capacity of from 30 to 50 per cent in excess of the total number of burners installed.

(3) For saloons and all night or continued service, the generator to have a rated capacity of from 100 to 200 per cent in excess of the total number of burners installed.

c. A small generator should never be installed to supply a large number of lights, even though it seems probable that only a few lights will be used at a time. An overworked generator adds to the cost of producing acetylene gas.

5. CARBIDE CHARGES.—To be sufficient to furnish gas continuously for the maximum lighting period to all burners installed. In determining charges lump carbide to be estimated as capable of producing 4½ cubic feet of gas to the pound, commercial ¼-inch carbide 4 cubic feet of gas to the pound, and burners to be considered as requiring at least twenty-five per cent more than their rated consumption of gas.

6. BURNERS.—Burners consuming one-half of a cubic foot of gas per hour are considered standard in rating generators. Those having a greater or less capacity will decrease or increase the number of burners allowable in proportion.

Burners usually consume from 25 to 100 per cent more than their rated consumption of gas depending largely on the working pressure. The so-called ½-foot burner when operated at pressures of from 20 to 25 tenths inches water column (2 to 2½ inches) is usually used with best economy.

7. PIPING.—*a.* Connections from generators to service pipes must be made with right and left thread nipples or long thread nipples with lock nuts. All forms of unions requiring gaskets are prohibited.

b. Piping, as far as possible, to be arranged so that any moisture will drain back to the generator. If low points occur of necessity in any piping, they are to be drained through tees into drip cups permanently closed with screw caps or plugs. No pet-cocks to be used.

c. A valve and by-pass connection to be provided from the service-pipe to the blow-off for removing the gas from the holder in case it should be necessary to do so.

d. The schedule of pipe sizes for piping from generators to burners should conform to that commonly used for ordinary gas, but in no case are the feeders to be smaller than three-eighths inch.

The following schedule is advocated:

⅜ inch pipe, 26 feet, three burners.
½ inch pipe, 30 feet, six burners.
¾ inch pipe, 50 feet, twenty burners.
1 inch pipe, 70 feet, thirty-five burners.
1¼ inch pipe, 100 feet, sixty burners.
1½ inch pipe, 150 feet, one hundred burners.
2 inch pipe, 200 feet, two hundred burners.
2½ inch pipe, 300 feet, three hundred burners.
3 inch pipe, 450 feet, four hundred and fifty burners.
3½ inch pipe, 500 feet, six hundred burners.
4 inch pipe, 600 feet, seven hundred and fifty burners.

e. Machines of the carbide feed type are not to be fitted with continuous drain connections leading to sewers, but must discharge into suitable open receptacles which may have such connections.

f. Piping to be thoroughly tested both before and after the burners have been installed. It should not show loss in excess of two inches of mercury within twelve hours when subjected to a pressure equal to that of fifteen inches of mercury.

g. Piping and connections to be installed by persons experienced in the installations of acetylene apparatus.

8. CARE AND ATTENDANCE.—In the care of generators designed for a lighting

period of more than 5 hours always clean and recharge the generating chambers at regular stated intervals regardless of the number of burners actually used.

Where generators are not used throughout the entire year always remove all water and gas and clean thoroughly at the end of the season during which they are in service.

It is usually necessary to take the bell portion out and invert it so as to allow all gas to escape. This should never be done in the presence of artificial light or fire of any kind.

Always observe a regular time, during daylight hours only, for attending to and charging the apparatus.

In charging the generating chambers of water-feed machines clean all residuum carefully from the containers and remove it at once from the building. Separate from the mass any unslacked carbide remaining and return it to the containers, adding new carbide as required. Be careful never to fill the containers over the specified mark, as it is important to allow for the swelling of the carbide when it comes in contact with water. The proper action and economy of the machine are dependent on the arrangement and amount of carbide placed in the generator. Carefully guard against the escape of gas.

Whenever recharging with carbide always replenish the water supply and in carbide machines be careful not to place in the generator less than one gallon of water for each pound of the carbide capacity, and not to bring the water above the point marked on the machine as the proper level.

Never deposit residuum or exhausted material from water-feed machines in sewer pipe or near inflammable material.

Never recharge carbide feed generators with carbide without first cleaning out the generating chambers and completely refilling with clean water.

Never test the generator or piping for leaks with a flame, and never apply flame to an outlet from which the burner has been removed.

Never use a lighted match, lamp, candle, lantern or any open light near the machine.

Failure to observe the above cautions is as liable to endanger life as property.

9. OUTSIDE GENERATOR HOUSES.—*a.* Outside generator houses should not be located within five (5) feet of any opening into, nor shall they open toward any adjacent building, and must be kept under lock and key.

b. The dimensions to be no greater than the apparatus requires to allow convenient room for recharging and inspection of parts.

c. Generator houses to be thoroughly ventilated, and any artificial heating necessary to prevent freezing shall be done by steam or hot water systems.

Class B—Stationary Non-Automatic Apparatus

10. FOUNDATIONS.—*a.* To be of brick, stone or concrete.

b. To be so arranged that the machine will be level and so that strain will not be brought upon the connections.

11. GAS HOUSES.—*a.* To be constructed entirely of non-combustible material and must not be lighted by any system of illumination involving open flames.

b. To be heated, where artificial heating is necessary to prevent freezing, by steam or hot water systems, the heater to be located in a separate building, and no open flames to be permitted within generator enclosures.

c. To be kept closed and locked excepting during daylight hours.

d. To be provided with a permanent and effective system of ventilation which will be operative at all times, regardless of the periods of operation of the plant.

12. ESCAPE PIPES.—Each generator to be provided with a vent pipe of ample size, substantially installed, without traps. It should be carried to a suitable

point outside the building and terminate in an approved hood located at least twelve feet above ground and remote from windows.

The hood is to be constructed in such a manner that it cannot be obstructed by rain, snow, ice, insects or birds.

13. CARE AND MAINTENANCE.—All charging and cleaning of apparatus, generation of gas and execution of repairs to be done during daylight hours only, and generators are not to be manipulated or in any way tampered with in the presence of artificial light.

This will require gas-holders of a capacity sufficient to supply all lights installed for the maximum lighting period, without the necessity of generation of gas at night or by artificial light.

In the operation of generators of the carbide-feed type it is important that only a limited amount of carbide be fed into a given body of water. An allowance of at least one gallon of generating water per pound of carbide must be made in every case, and when this limit has been reached the generator should be drained and flushed, and clean water introduced. These precautions are necessary to avoid overheating during generation and accumulation of hard deposits of residuum in the generating chamber.

Class C—Semi-Portable Automatic Acetylene Apparatus

FOUNDATIONS.—(a) Should be so arranged as to afford proper support for the weight involved. If of wood, they shall be located in a dry place open to the circulation of air.

(b) To be so arranged that the machine will be level, and so that unequal strain will not be placed on the generator or connections.

(c) The generator must be so installed as to prevent accidental overturning.

LOCATION.—(a) Generators to be so placed that the operating mechanism will have room for free and full play and can be adjusted without artificial light. They must not be subject to interference by children or careless persons, and if for this purpose further enclosure is necessary it must be furnished by means of slatted partitions, permitting the free circulation of air.

(b) Generators which from their construction are rendered inoperative during the process of recharging to be so located that they can be recharged without the aid of artificial light.

(c) Generators to be placed where water will not freeze.

ESCAPES OR RELIEF PIPES.—If escape or relief pipes are required, they should conform to rule for the installation of other acetylene apparatus. (See Rule 3.)

PIPING.—(a) Shall conform to Rule 7, except that seamless brass tubing may be employed provided the generator is so designed that in case of a break anywhere in the distributing system, the machine will be inoperative.

(b) If conditions for recharging are such that the machine must be disconnected from the piping system, it may be connected with the piping by metal tubing or pipe having sufficient flexibility through U-bend or coil to allow necessary adjustment for making connection without undue strain on material or joints.

(c) Tubing must be of sufficient internal diameter to insure adequate supply of gas with normal working pressure at the generator.

(d) Tubing must be of sufficient thickness to safely withstand pressure of 500 pounds per square inch, and in no case lighter than ⅛-inch outside diameter with 1/64-inch walls.

(e) Must not be secured in place with staples unless bushed, and must be suitably protected from mechanical injury wherever the distance above the floor is less than 5 feet.

Must be protected by sleeves where passing through floors, walls or partitions.

Must be supported in ceiling runs at intervals not exceeding 6 feet.

REGULATIONS FOR THE INSTALLATION AND USE OF COAL GAS PRODUCERS*

NOTE.—These are installation rules only and are not to be considered as specifications for the construction of Coal Gas Producers.

1. PRESSURE SYSTEMS.—All pressure systems must be located in a special building or buildings approved by Inspection Department having jurisdiction for the purpose, at such distance from other buildings as not to constitute an exposure thereto, except that approved pressure systems without gasometer having a maximum capacity not exceeding 250 horse power and with pressure in generator not exceeding two pounds, may be located in the building, provided that the generator and all apparatus connected therewith be located in a separate fireproof room, well ventilated to the outside of the building; every communication if any to be protected by an approved fire door. In all other respects the apparatus must comply with the requirements for suction systems.

EDITOR'S NOTE.—The pressure type of system introduces an explosion hazard to a slight degree, making the building best suited one of light non-combustible character. For both types of producers, the hazard of coal storage is the same as for a boiler plant.

2. SUCTION SYSTEMS.—(a) Approved suction gas producers may be located inside the building, provided the apparatus for producing and preparing the gas is installed in a well-ventilated room. At no time shall the internal pressure of the producer be in excess of atmospheric pressure.

NOTE.—The installation of gas producers in places where open lights or fires are used may be permitted by special permission of the Inspection Department having jurisdiction.

(b) The smoke and vent pipe shall, where practicable, be carried above the roof of the building in which the apparatus is contained, and above adjoining buildings. When buildings are too high to make this practicable the pipe shall end at least 10 feet from any wall opening.

No smoke nor vent pipe shall be within 9 inches of any woodwork or any wooden lath and plaster partition or ceiling.

Where smoke and vent pipes pass through combustible partitions they shall be guarded by galvanized iron ventilated thimbles at least 12 inches larger in diameter than the pipes, or by galvanized iron thimbles built in at least 8 inches of brickwork or other incombustible material. They shall not under any circumstances be connected into chimneys or flues except that the pipe may pass up in flues used for no other purpose. No smoke pipe shall pass through any floor nor through a roof having wooden framework or covering.

(c) Platforms used in connection with generators must be incombustible.

(d) The producer and apparatus connected therewith shall be safely set on a solidly built masonry foundation.

(e) While the plant is not in operation the connection between the generator and scrubber must be closed and the connection between the producer and vent pipe opened, so that the products of combustion can pass into the open air. This must be accomplished by means of a mechanical arrangement which will prevent one operation without the other.

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*As recommended by the National Board of Fire Underwriters.

(f) The producer must have sufficient mechanical strength to successfully resist all strains to which it will be subjected in practice.

(g) Wire gauze not larger than 30 mesh to the inch or its equivalent must be used in the test pipe outlet.

(h) If illuminating or other pressure gas is used as an alternative supply, the connections must be so arranged as to make the mixing of the two gases or the use of both at the same time impossible.

If illuminating or other pressure gas is used as a supplementary supply, mixing of the two gases may be permitted if a suitable device is provided to prevent the supplemental gas from entering any part of the producer gas equipment, including the scrubber or purifier.

(i) The opening for admitting fuel shall be provided with some charging device so that no considerable quantity of air can be admitted, or gas escape, while charging.

(j) Before making repairs which involve opening the gas passages to the air, the producer fire must be drawn and quenched and all combustible gas blown out of the apparatus through the vent pipe.

(k) Except for pressure producers, the opening for admitting air into the producer during operation may be inside the building subject to the approval of the Inspection Department having jurisdiction.

(l) The apparatus must have name plate giving the name of the device, capacity and name of maker.

NOTE.—For installation of engines used in connection with these producers, see Regulations for Internal Combustion Engines.

Hazard of Electric Lamps

The U. S. Bureau of Mines, as the result of an investigation, reports that the naked filaments of all standard lamps, energized at rated voltage, will ignite explosive gaseous mixtures; that all classes of standard carbon lamps will sometimes ignite gas when the tips of the bulbs are broken off; that the filament temperature of all classes of standard lamps and of all but one class of miniature lamps can be increased to such a degree that the lamps when smashed will ignite gas; that several classes of both standard and miniature lamps when smashed while burning at rated voltage will invariably ignite gas.

The Underwriters' Laboratories list a watchman's portable electric safety lamp, consisting of a lead plate, 2 V. storage battery enclosed in aluminum case. A small incandescent lamp, together with a special switch, safety glass and shells are mounted on the top of casing. For watchman's use. Also a miners' portable electric safety lamp, consisting of a battery, reflector and safety features same as watchman's lamp. Battery is enclosed in a case for fastening to miner's belt, and reflector is designed to fasten to miner's cap. Electrical connection is made between the two by length of small armored cord and bayonet receptacles and plugs. For use in mines.

Fire hazard of these lamps under any conditions liable to be met in service is judged to be practicably negligible, although it is recognized that under conditions remotely possible the more explosive vapors can be ignited by the hot filaments exposed by breaking of lamps used.

The results of tests, supplemented by reports of extensive field experience, indicate that these lamps are suitable for general use and are especially suitable for use wherever flammable or explosive vapors or gases are liable to be encountered.

Gas Shut-Off Valves

Owing to the fact that fires are frequently caused or increased in volume as a result of the escape of inflammable gases, which cannot be readily controlled on account of the inaccessibility or absence of shut-off valves in the system of piping, or on account of the fact that ordinary valves where installed may not be operative after long standing, a properly located manually operated valve in such piping should be provided.

The Underwriters' Laboratories list several makes of gas shut-off valves. The equipment consists essentially of a valve connected by a protected rod or cable with a control handle in a pull box located at some readily accessible point.

As given in the regulations issued by the National Board of Fire Underwriters issued in 1913 the installation should be as follows:

INSTALLATION.—a. Shut-off valve preferably to be located in a substantially constructed pit outside the building wall. Pit to be provided with a locked cover and to be no larger than necessary to allow the proper inspection and adjustment of the valve. Valve should be protected against freezing.

NOTE.—Inspection departments and local authorities having jurisdiction to be consulted when the valve cannot be located as specified above. When necessarily installed inside of building, valve to be located as near as possible to the point where gas main enters building.

b. The installation of the valve to be such that the hazards from falling walls, etc., will be minimized.

c. The valve to be located in such a manner that it may be readily inspected and reset by authorized persons.

d. The valve to be protected from accumulation of moisture as far as practicable, and to be kept free from accumulation of lumber or other material.

e. Control handle for closing valve to be in a locked metal pull box provided with a glass or metal cover suitably marked to designate its purpose. Pull box to be located so that it will be readily accessible from outside of building, and to be secured to a non-combustible wall where possible.

f. Connection between valve and control handle to be run as directly as practicable, and to be entirely enclosed in galvanized iron or steel pipe or approved conduit to prevent interference with operation, accidental closure, or tampering.

NOTE.—Connection between valve and control handle by means of a single direct rod is preferred. Where the character of the installation is such that the direct-rod connection is impracticable the use of a cable connection, if acceptable to inspection departments and local authorities, may be permitted.

g. Where a cable connection is used between valve and control handle, the conduit is to be securely anchored and provided with suitable roller fittings at angles which will prevent sticking of the cable.

NOTE.—Bends in conduit and unnecessary joints which are liable to cause friction or lost motion, are to be avoided.

h. Supplementary pull boxes for operating valve from inside of building, if used, must be so arranged that they will not in any way interfere with the manual operation referred to above.

NOTE.—Supplementary controls are not to be used unless acceptable to inspection departments and local authorities, who should be consulted in reference to location of control stations.

i. Valve mechanism and pull boxes to be locked so as to be accessible only to authorized persons.

NOTE.—Automatic means for closing valves may be of value for the protection of fusible meters or connections. Where meters and connections are of such construction that gas will not escape in case of fire an automatic control is of little value and may lead to the premature extinguishment of the lights in the building.

CARE AND ATTENDANCE.—The valve and its attachments should be inspected at least once every six months, and after a valve has been used to shut off the gas it should be reset only by authorized persons.

CONSTRUCTION AND OPERATION OF LAUNDRIES*

No combustible material shall be permitted in the construction of any laundry drying room hereafter erected in hotels, apartments, tenements, asylums, convents, prisons, and similar public institutions.

NOTE.—It is strongly recommended that all laundry drying rooms be made of incombustible materials. The extra cost of such fireproof construction is not excessive and this is offset by the increased life of the structure. The reduction in fire hazard by the use of such construction is very marked.

If drying rooms are constructed of wood, the inside surface of all walls, ceilings, partitions, and doors, shall be covered in every part with a layer of sheet asbestos not less than ⅛ inch thick; and over this a layer of sheet metal. The metal shall be nailed in place with locked joints covering the nail heads.

If wheel racks are used which roll on the floor of the drying room, the floor shall be covered with heavy sheet steel suitable to resist the wear of the wheels; or it may be covered with brick, concrete, tile, or any incombustible composition flooring approved by the Superintendent of Buildings. If drying racks are of such type as not to abrade the floor, it may be covered the same as the sides and ceiling.

If any windows are placed in drying room walls or ceilings, they shall be glazed with wired glass, set in stationary approved metal sash.

If a vent pipe be used in connection with a drying room, it shall be wrapped its full length with sheet asbestos, corrugated asbestos, or some equivalent fireproof material satisfactory to the Superintendent of Buildings. Such covering shall be not less than ⅛ inch in thickness, and shall be securely attached to the pipes with wire or metal bands.

No part of a vent pipe shall be placed nearer than 6 inches to any exposed woodwork.

In the vent pipe, in or near the drying room, there shall be placed a fine wire screen to catch the lint and dirt that is drawn out of the drying room. The screen shall be arranged to permit of easy removal for purpose of cleaning, and it shall be the duty of the person in charge of the drying room to see that the screen is kept clean.

NOTE.—For requirements for ventilating systems, see page 204.

The inside of the drying room shall be thoroughly cleaned at least once a week to remove any dust or lint that may have accumulated therein.

The dust and lint shall be thoroughly cleaned from all dryroom tumblers, ironing machines, and mangles at least once per month. Particular attention shall be paid to cleaning the driving mechanism where such accumulations may be saturated with oil.

NOTE.—These precautions are taken because of the well recognized danger of fire due to an accumulation of lint and dust in conjunction with the inevitable spark from some unexpected source. Even spontaneous combustion is known to have started such a fire.

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*Abstracted from a suggested ordinance issued by the National Board of Fire Underwriters.

Ventilating fans for drying rooms shall be constructed entirely of metal, and shall have all bearings outside, and easily accessible for oiling and daily inspection.

Fans shall be so installed as to be automatically stopped when the temperature around them reaches 300 degrees F.

All heating pipes in drying rooms, whether single or in coils, shall be in vertical tiers and be protected by wire screens of a mesh not exceeding ½ inch. Such screens shall be rigidly placed at a distance of not less than 2 inches from the pipes or their connections in every part. The screens shall be conveniently removable for purposes of repairing pipes or removing dust therefrom.

No stove or any heating appliance burning gas, gasoline, coal or other fuel shall be permitted in any drying room.

No gas lights or lamps of any kind shall be permitted in any drying room.

No combustible material of any character shall be allowed to be stored or to accumulate upon the top or against the sides of any drying room.

In all wooden drying rooms hereafter erected, there shall be introduced through the ceiling or near it, a one-half inch live steam pipe directly connected to the boiler. Said pipe shall be fitted in the drying room with automatic sprinkler heads set to open at 300 degrees F. The number and location of heads to be controlled by the standard sprinkler rules of the National Board of Fire Underwriters, and there shall be a "sealed open" cut-off valve in the boiler room which can be closed in case of emergency, or for repairs.

In lieu of this steam pipe connection, the drying room may be protected by automatic sprinklers installed under the ceiling according to the sprinkler rules of the National Board of Fire Underwriters, except that the water may be taken from the city supply, provided it will give a pressure of 10 pounds at the sprinkler heads with all heads open. All sprinkler heads shall be set to open at 300 degree F.

Combustible floors under dryroom tumblers, or other similar apparatus using steam from a boiler rated at 50 pounds pressure or over, shall be protected by a sheet of metal over a ⅛ inch layer of asbestos or asbestos building lumber.

All stoves used for laundry purposes in non-fireproof buildings shall be supported on metal legs not less than 6 inches in length.

A combustible floor under a laundry stove shall be protected by a ⅛ inch layer of sheet asbestos or asbestos building lumber, upon which a course of hollow brick shall be laid in cement mortar; and over the brick there shall be placed a sheet of galvanized iron of a thickness not less than No. 26 gage. The whole protection shall extend 24 inches beyond the stove on all sides.

The sheet metal may be lapped down over the sides of the layer of brick and be nailed to the floor to assist in holding the brick in place, but the metal must not project over the ends of the brick sufficiently to cover any portion of the hollow spaces and thereby obstruct a free circulation of air.

The installation of laundry stoves as regards their proximity to wooden partitions, ceilings, or furred walls, shall conform in all particulars to the requirements for stoves and ranges presented on page 340.

All machines used for ironing or finishing purposes which are heated by gas or any volatile inflammable fluid, shall, so far as possible, be vented by metal pipes into some safe place outside the building, or into a chimney flue. In no case shall the vent opening of such machines be permitted to face any passageway, nor any part of a laundry floor where operatives would be stationed, or likely to pass within a distance of 5 feet of the vent. All such machines shall be placed at least 2 feet from any woodwork.

Collar or cuff shapers, or stands for sad or polishing irons, which are heated by gas, or any volatile inflammable fluid, and rest on wooden tables, floors, or other wooden supports, shall have between them and the woodwork a ⅛ inch layer of asbestos or asbestos building lumber, covered with a sheet of metal. The aforesaid protective material shall extend the full size of the heating appliance. No such heating stand shall be placed nearer than 18 inches to any combustible wall or partition unless such wall or partition be protected in the same manner as specified for tables.

No rubber or other combustible tubing or hose, shall be used for gas connections to any laundry heating appliance, except that necessary for certain types of flat irons which are used while being heated. All other connections shall be made with standard metal pipe and fittings.

The gas used for heating purposes shall be supplied by a system of piping entirely separate from that used for lighting, and the main supply pipe for the heating system shall have a cut-off valve near the meter which shall be closed at the end of each day's work.

No matches other than safety matches shall be permitted to be used in any laundry.

NOTE.—Some careful laundrymen require that all gas heated laundry appliances be ignited by means of a wax taper, or a portable electric gas lighter. This practice is commended.

It shall be the duty of the manager or person in charge of the laundry to see that the gas is shut off from all ironing or other heating surfaces at the close of each day's work, and that all sad, polishing, or other such irons are placed on some incombustible support.

He shall also see that no combustible material be allowed to accumulate about any of the heating machines. All waste paper or other combustible material shall be kept in metal cans.

If the packing room and the laundry adjoin, they shall be separated by a fireproof partition.

NOTE.—Sections covering electric wiring, volatile inflammable liquids, gas and acetyline are omitted as being covered by other parts of this book.

EXPLOSIBILITY OF GRAIN DUST.*

Origin and Distribution of Dusts.—During the process of handling grain large quantities of dust are produced. The coarse or heavier dust settles on the floors, steps, machinery, etc., while the very fine dust rises into the atmosphere, and settles on beams, rafters and other inaccessible points. The bolters, rolls, purifiers, etc., all produce a large quantity of dust during their process of operation, and if a satisfactory system of dust collecting is not installed a portion of the dust may escape into the surrounding atmosphere. During the grinding process considerable dust may also escape into the air if proper provisions are not taken to keep the machinery in repair. The conveyor lines and elevator legs, in case of any defect in construction, will allow the dust to enter the surrounding air. At the discharging point of grain into storage, an opportunity is given for the dust to escape into the air and settle on surrounding projections. In addition to the various sources enumerated, there are possibly a number of others, but the ones mentioned generally cover the sources that produce the largest quantity. An important consideration in the prevention of the accumulation of dangerous dusts would be to attack the point where the dust is produced, and not deal exclusively with its removal after it has settled in dangerous quantities. It is true that the escape of dust cannot be entirely prevented, but it can be reduced to such an extent that its complete removal can be more certain.

Efficiency of Dust-Collecting Systems.—The introduction of dust-collecting systems in the milling industry has succeeded in the practical elimination of the old dust or "stive" room. When this dust room was in use, such as at the time of the Minnesota explosion in 1878, and the Illinois explosion in 1893, the dust was conveyed or carried to the "stive" room from the various parts of the mill. This always made an "explosive chamber," as it were, allowing sufficient dust to be in suspension to produce a violent explosion, if ignited. With the present system of dust collection as applied to modern mills this particular source of danger is done away with, and, by means of air currents, the dust is carried to the collector and deposited. Many millers seem to feel a sense of security if such a dust-collecting system is in good working order, and that this danger from explosions is practically eliminated. Owing to the difference in types of grinding machines used in flour and feed milling, the flour miller feels an additional amount of protection from the fact that a series of sparks necessary to ignite the dust cloud will not be as readily produced by the grinding "rolls" as when attrition or friction mills are used. However, it would not be advisable to conclude that flour mills are not as liable to experience explosions as feed or cereal mills, owing to this one difference of machinery installation, as other sources are often present which may cause a spark or fire and generate an explosion which would extend to the highly inflammable dust usually prevalent in any grinding mill.

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* Abstracted from a report of the U. S. Bureau of Mines.

Observations in various mills would seem to indicate that at times some of the dust collectors do not work as effectively as at other times. In some cases dust has been in suspension, forming a noticeable cloud near the collecting device, probably due to defective equipment. When this occurs the very finest part of the dust leaks out into the atmosphere, and when mixed with sufficient air forms a dangerous mixture.

Laboratory Investigations of Inflammability of Grain Dust.—Following the disaster in Minnesota in 1878, Professors Peck and Peckham carried out some tests upon the explosibility of flour dusts. They found that two ounces of these dusts together with two cubic feet of air would produce, when ignited in a box with a frame, an explosion that would lift two men standing on the cover. It has been calculated that a sack of flour suspended as dust in 4,000 cubic feet of air (a room 20x20x10), when ignited, would generate sufficient force to throw 2,500 tons 100 feet high.

More recent work upon the inflammability of carbonaceous dusts has been carried out by R. V. Wheeler, Chief Chemist for the Explosion in Mines Committee, England. He tested a large number of various kinds of dusts by two different methods—one for the purpose of discriminating between harmless and dangerous dusts; the other with the intention of ascertaining the temperatures at which inflammation of the dangerous dusts takes place readily. As a result of these tests he divided the dusts into three classes, namely:—

> "Class I.—Dusts which ignite and propagate flame readily, the source of heat required for ignition being comparatively small; such, for example, as a lighted match.
>
> "Class II.—Dusts which are readily ignited, but which for the propagation of flame require a source of heat of large size and high temperature (such as electric arc), or of long duration (such as the flame of a Bunsen burner).
>
> "Class III.—Dusts which do not appear to be capable of propagating flame under any conditions likely to obtain in a factory; either (a) because they do not readily form a cloud in air, or (b) because they are contaminated with a large quantity of incombustible matter, or (c) because the material of which they are composed does not burn rapidly enough."

Class I

Sugar
Dextrine (calcined farina)
Starch
Cocoa
Rice, meal and sugar refuse
Cork
Unextracted soya bean
Wood flour
Malt
Oat husk
Grain (flour mill)
Maize
Tea
Compound cake
Grain (grain storage)
Rape seed
Cornflour
Flour (flour mill)
Chicory
Briquette
Gramophone record
Extracted soya bean

Class II

Copal gum
Leather
"Dead" cork
Cocoanut oil milling
Oil cake
Offal grinding (bran)
Grist milling
Horn meal

Rice milling
Sawdust
Castor oil meal

Mustard
Shoddy
Shellac composition

Class III

Organic ammonia
Tobacco
Spice milling
Bone meal
Coal (foundry blacking)
Lamp black
Sack cleaning
Retort carbon
Rape seed (Russian)
Blacking
Grain cleaning

Drug grinding
Cotton seed
Cotton seed and soya bean
Charcoal
Foundry blacking
Brush carbon
Stale coke
Plumbago
Bone charcoal
Mineral and ivory black

The classification, as here given, is according to the inflammability of the sample tested. Other results might be obtained from other samples of the same material, especially those placed in Class III.

The U. S. Bureau of Mines, after a series of tests, reports that:

> "Although sufficient work has not been done to allow of any absolute statements, the results thus far indicate that all dusts that are made in the handling and working up of grain into food products can be ignited under proper conditions, and also will propagate a flame, most of them with explosive violence. This statement should not be taken as meaning that the dusts will ignite of themselves, that is, spontaneously; but when heated to their ignition-temperature will ignite and will propagate a flame. In other words, there must be some outside source of heat. This may be very small, such as a heated coil of wire, as used in the above tests, if the temperature is sufficiently high; or it may be larger, as a flame, which may have a lower temperature but a larger heating surface."

Amount of Dust that will Propagate an Explosion.—In dust explosions usually two reports are heard; the first is described as a sharp, quick sound, followed by a second of a loud, rumbling nature, and lasting for a much longer period and usually followed by fire, destroying the plant. The theory of this is that a very small quantity of fine dust in suspension becomes ignited, causing the first sharp report, which would produce sufficient concussion to disturb settled and packed dust on surrounding ledges and projections, filling the air with an additional explosive mixture. The heat, or flame from the original small puff, would cause an ignition of this newly formed mixture, and the explosion would propagate throughout a very large area, until the entire dust zone would be covered. Because of the possibility of this, it is necessary to prevent even small accumulations of dust, particularly near points from which sparks or flame may originate.

Many theories and ideas have been advanced as to the conditions under which dust explosions are produced and the amount of dust in suspension necessary to originate the explosion, all probably based on different tests and experiments. It is generally agreed that the dust must be fine and dry, and in a state of suspension in the atmosphere, and there must be a proper proportion in diffusion so that the explosive mixture will ignite with sufficient force to propagate to an explosion. It is therefore evident that to prevent explosions practically all the dust must be removed, or the amount of air kept down to a minimum.

Causes of Grain-Dust Explosions.—The following causes have

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been assigned to many of the explosions in milling plants throughout this country and abroad:

(1) Use of open lights, or naked flames, such as lamps, torches, gas jets, lanterns, candles, matches, etc.

(2) Property fires.

(3) Introduction of foreign material in grinding machines.

(4) Electric sparks from motors, fuses, switches, lighting systems.

(5) Static electricity produced by friction of pulleys and belts, grinding machines, etc.

A detailed discussion of the first two classes is not necessary; recognizing the explosive hazard of dust laden air, it is obvious that all the causes in (1) should be guarded against. Many violent explosions have occurred during mill fires, as the force from the fire produces sufficient concussion to jar accumulated dust into suspension.

A large number of explosions in more recent years have been traced to the introduction of foreign materials into grinding machines, particularly in grinding oat hulls and feeds. Particles of foreign material seem to pass the separating systems and, coming in contact with the grinding plates of the machines, produce sufficient sparks to cause an ignition of the dusts in the grinding machines and conveyor lines.

Explosions have been assigned to the ignition of the dust cloud by an electric arc, and by sparks from motors, blown fuses, switchboards, starting boxes, lighting systems, etc. A disastrous explosion in Liverpool, England, in 1911, was due to the ignition of dust stirred up by the breaking of a belt. The cause of the ignition was due to sparks from a blown fuse of a temporary switchboard.

The production of static electricity by friction of pulleys and belts has been assigned as the cause of recent dust explosions. Although experiments have not been conducted along this line to show that a dust cloud can be ignited in this manner, a recent experiment by the U. S. Bureau of Mines showed very clearly that sufficient static electricity could be produced by a very small pulley and shaft to readily ignite gas. A milling company in Texas, engaged in grinding cottonseed cake into meal, states, that after experiencing a series of explosions, the insulating of a certain grinding machine prevented any repetition of previous occurrences. The fact that explosions have been known to occur at times when the feed of grinding machines was cut off, seems to indicate that an unknown factor may be the responsible agent.

Prevention of Grain-Dust Explosions.—Since only a very small quantity of dust in suspension is necessary to present conditions favorable to ignition, it would appear advisable that the proper thing to do would be to avoid the production or escape of dust into the atmosphere, as far as this is possible. From the large number of explosions thought to have been due to the presence of foreign material in the grain, it appears that the grain contains a portion of this material from the original point of shipment and suggests the importance of cleaning the grain at the very first stages of handling. In addition to this source of danger the size of the bins receiving ground material has an important relation to the extent of the fire or the violence of the explosion. If the bin is of large dimensions and very deep, it gives a very large area that may become filled with very fine dust in suspension. A number of violent explosions have occurred, due to a flame coming in contact with the suspended dust in bins containing only a small quantity of grain.

It is necessary in mills and elevators, for the workmen to determine at frequent intervals the amount of grain that the storage bins contain. A common practice is to lower a light of some kind into the bin, to observe or measure the quantity of grain. Many explosions have occurred when open lights and lanterns were introduced into grain bins for this purpose, and the practice cannot be too strongly condemned. The relation of the electric spark to the ignition of the dust cloud has not been fully determined by experiment, and many companies, for this reason, have discontinued the lowering of incandescent electric light bulbs into dusty atmospheres. There is a tendency for the workmen to become hasty in an effort to ascertain the quantity in a series of bins, and the bulb may, by contact with the side of the bin or floor, become broken and introduce an element of possible danger. The desired result can be obtained by lowering a "tape" with a weight attached to the end, and the exact measurement can be recorded.

Where lights must be used an approved type of portable electric lamp should be provided. The Electrical Section of the Bureau of Mines has recently approved three different types of lamps for safety in gaseous mixtures.

Electric bulbs in dusty atmospheres located near machinery where there is a possibility of the lamp becoming broken, or at points in the mill where workmen may strike the lamp, especially when carrying a projection of some kind on their shoulder, should be enclosed in strong wire guards or protectors; and it would be advisable also to enclose each bulb in a vapor-proof globe. An extra safety feature would be, whenever possible, to locate all fuses on light and power circuits, switches, starting boxes, motors, etc., at points where dust is not present in dangerous quantities.

An adequate system of preventing or collecting dust should be provided and maintained; in fact, from the point where the grain or other material enters the building to its final distribution, it should not be allowed to be discharged or moved in such a manner that dust may escape.

At any point where open delivery is necessary, powerful suction dust collectors should be provided. To prevent explosions due to sparking in milling machinery, vents are often provided; these are essentially safety or explosion valves, to permit the release of pressure caused by incipient explosions; to be of value they must be of good size, and under no circumstances should they open into any part of the building. Lately experiments have been made with checking devices which hold back a sufficient amount of the material to almost completely exclude any air at the point where sparks may be expected; such an appliance, when perfected, will tend largely toward reducing the hazard of explosions originating or traveling through conveyors and machinery.

Besides the dust collecting systems, the removal of dust which has settled in the mill is necessary. The usual method is to sweep up the floors with a broom and dust off all rafters, etc. This removes the larger particles and much of the real dust, but the finest and, therefore, most dangerous dust is only stirred up to mix with the fine particles already in the air. In any of the larger mills and in any dust laden section of a smaller plant a complete vacuum cleaning system should be installed, similar to that used by the housewife in cleaning her home. The cost of installation may be high but the thoroughness is undisputed and it will save in the number of employees usually necessary for cleaning.

BLOWER SYSTEMS*

Blower systems, which are often an economic necessity, usually introduce an additional hazard contributing to the cause and spread of fire, particularly when used for conveying stock and refuse. It is impossible to eliminate the fire hazard from such systems, but reasonable safeguards can be provided to reduce it.

The general standards applicable to blower systems are subdivided into two classes:—

A. Heating and Ventilating Systems.

B. Stock and Refuse Conveying Systems.

Class A—Heating and Ventilating Systems

1. **Blowers.** (The word blowers is used to include blowers and fans.)

(a) Blowers shall be so located as to be accessible for repairing and lubricating.

(b) Casings to be strongly built and properly reinforced where necessary; joints shall be air-tight.

Casings and runners shall be entirely non-combustible, and large enough not to require overspeeding.

To prevent accidents, openings into casings shall be protected with substantial screens or their equivalent.

(c) Bearings and journals to be constructed in accordance with the best modern machine design and so proportioned as to prevent over-heating. The bearings shall be self-oiling and so designed as to prevent leakage of oil. They shall be located outside of casings or ducts wherever possible. If located inside of casings or ducts, oilless self-lubricating bearings shall be used, made of bronze bushings fitted with plugs, such as graphite or metaline.

2. **Ducts.** (The word ducts is used to include ducts, flues, pipes and tubes.)

(a) Openings through floors for the circulation of air from one story to another shall not be used.

(b) Entire system of ducts to be self-contained; no rooms, hallways, attics, hollow spaces, voids, nor other portions of the building shall be used for air chambers or ducts, unless of fire-resisting constructon, and then only by permission of the inspection department having jurisdiction.

(c) Ducts shall be made of galvanized iron or other approved non-combustible material. The same applies to enclosures of steam coils used for heating air.

(d) To be thoroughly braced.

(e) To be substantially supported by metal hangers, brackets or their equivalent.

(f) Where subject to mechanical injury, ducts to be properly protected.

(g) In no case shall the clearance between any metal ducts and combustible material be less than 1 inch.

(h) The passing of ducts through fire walls should be avoided wherever possible. Where ducts pass through fire walls they shall be provided with

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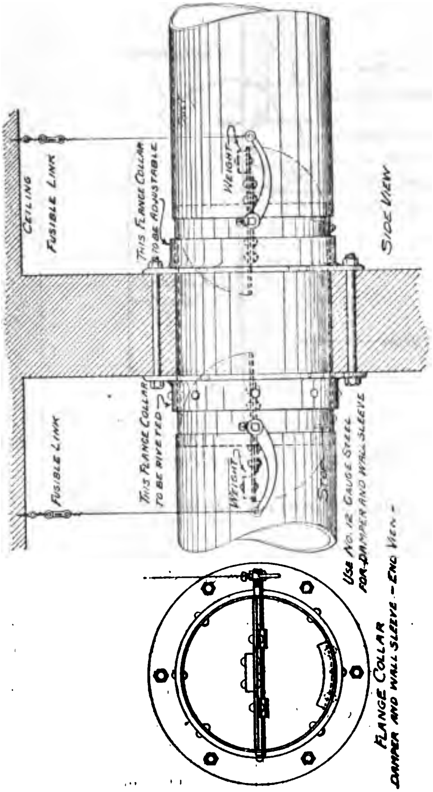
* From the Regulations issued by the National Board of Fire Underwriters in 1915.

automatic dampers, or national standard vertical automatic fire doors, located on each side of the wall through which they pass.


CEILING
FUSIBLE LINK
THIS FLANGE COLLAR TO BE ADJUSTABLE
WEIGHT
SIDE VIEW
FUSIBLE LINK
THIS FLANGE COLLAR TO BE RIVETED
WEIGHT
STOP
USE NO. 12 GAUGE STEEL FOR DAMPER AND WALL SLEEVE
FLANGE COLLAR DAMPER AND WALL SLEEVE - END VIEW

AUTOMATIC DAMPER FOR DUCT OPENINGS IN FIRE WALLS

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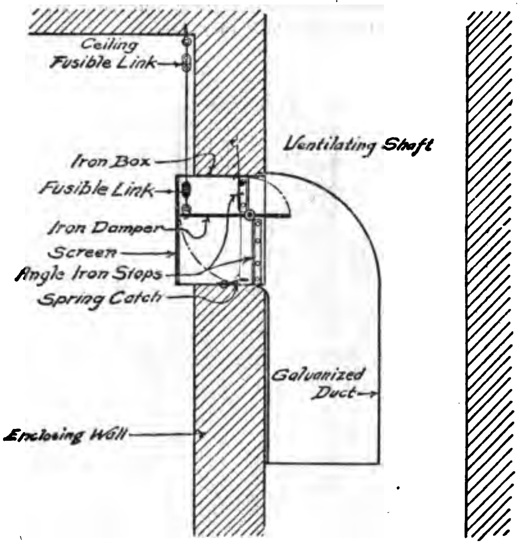
(i) All ducts passing through floors shall be made of or protected throughout by approved fire-resisting material, such as 4-inch brick, hollow tile, or 2-inch cement plastered partition supported by a substantial steel frame.

(j) Where a vertical duct has an outlet on more than one floor, automatic dampers shall be provided on all outlets opening directly from such vertical ducts and at all connections where ducts branch from such vertical ducts.

Editor's Note.—The object of these requirements is to prevent fire from spreading from one floor to another through ducts.

(k) Joints between ducts and floors, walls or partitions, must be made tight by non-combustible material.



TYPICAL AUTOMATIC DAMPER

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(l) Outlets on supply and exhaust ducts should always be protected by means of register faces or wire screens.

(m) Intake of air to be from outside except in re-circulating systems, and shall be taken only from areas containing non-combustible material. Intakes must be protected with rolling shutters or heavy doors.

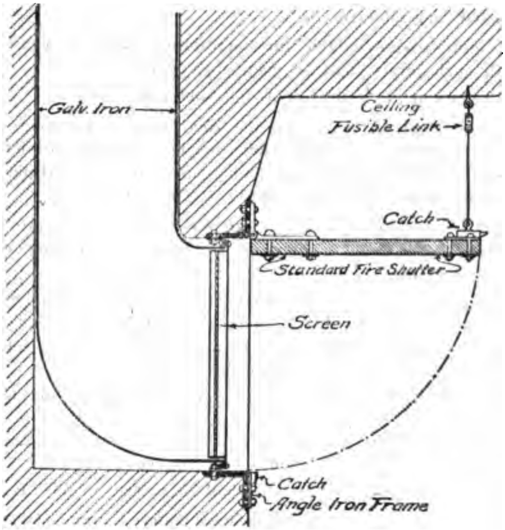
Intake and intake rooms, steam coils and blowers, etc., shall be segregated in a room cut off by fire-resisting partitions from other portions of the building.

(n) Blower systems should preferably have an emergency or automatic control to shut them down in case of fire. This may be done automatically by means of devices utilizing fusible links, thermostats, or automatic sprinklers. Such installations to be subject to the approval of the inspection department having jurisdiction.

3. VENTILATION OF COOKING APPLIANCES. (a) Ventilating ducts used to carry off the grease-laden vapors from hoods over cooking appliances, especially in kitchens of large restaurants and hotels, shall be constructed similarly to boiler smoke flues, and, if of metal, must be of not less than No. 16 U. S. gauge, so substantially built that the grease and gum could be removed from the interior by burning out under a flash fire.

(b) The ventilating ducts shall be an independent system in no manner connected with other house ventilating systems.

(c) Ducts should not be connected to stacks, chimneys or flues used for other purposes.



TYPICAL AUTOMATIC SHUTTER

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(d) A live steam jet should preferably be provided at the end of the duct nearest the cooking appliances.

Class B—Stock and Refuse Conveying Systems

The high velocity of the air and the inflammability of the stock or refuse which these systems are usually designed to handle make them especially hazardous.

The specific requirements of a ventilating system detailed under class "A" shall be applied to the stock and refuse conveying systems, also the following:

4. BLOWERS. (a) Blowers shall be installed on proper foundations and secured in place in a manner subject to the approval of the inspection department having jurisdiction.

(b) Bearings of blowers shall not extend inside of blower casings or ducts.

(c) It is recommended that oilless self-lubricating bearings be used, made of bronze bushings with plugs such as graphite or metaline.

(d) Connections between discharge end of blower and main duct must be made so as to prevent leakage of fine dust.

(e) Blowers through which inflammable materials pass shall have blades of composition, copper or brass. Ample clearance to be provided for all blades.

5. DUCTS. (a) Ducts for conveying stock and refuse shall be made of

suitable non-combustible materials, preferably galvanized iron. All joints shall be riveted and soldered.

(b) Lock joints are acceptable for longitudinal seams in pipes used under suction. All such joints shall be made dust proof.

(c) Spiral pipes to be full riveted and soldered.

(d) Provision shall be made for the wear due to friction, at all points of change of direction, by making long bends, by using heavier metal, and in case where abrasive materials are to be conveyed, by inserting an approved form of inside lining that may readily be renewed.

(e) Suitable tight-fitting sliding clean-out doors to be provided on all conveyor ducts at sufficient intervals to facilitate cleaning of ducts or removing obstructions.

(f) Suction ducts shall be provided at all machines producing dust or combustible refuse, and shall be connected to exhaust fans.

(g) "Sweep-up" pipes should be so protected as not to admit material which would be large enough to damage blower.

(h) Trunk line shall be run on the outside wall of the building with ducts from each machine and each floor, passing out directly through the wall and discharging into the trunk line. If inside of building, the trunk duct shall be overhead rather than under the benches.

(i) The air vents from the system shall discharge outside of building.

(j) Where dust or readily inflammable material can accumulate on or near blowers and ducts, they shall be grounded to prevent ignition of these materials from a discharge of static electricity.

6. AUTOMATIC SPRINKLERS. There shall be an approved sprinkler near the feed end, and at the discharge outlet, inside the condenser, if such is used, and also a sprinkler to protect the blower. In some cases, sprinklers may be installed inside the ducts. Such sprinklers should be arranged in an off-set or dome-shaped casing and not in the direct path of the draft. Sprinklers with smooth deflectors that will not catch the flying stock are desirable.

7. CYCLONE COLLECTORS OR SEPARATORS. (a) The cyclones or separators shall be outside the building, and so located as not to constitute a hazard to adjacent structures. Their construction and supports shall be of incombustible material. If the cyclone of necessity is placed within 10 feet of wooden walls, inflammable structures, or openings into buildings, it shall be provided with a metal pipe extending to a point above the main roof, or other safe location.

(b) The refuse from the cyclones and separators is to discharge by gravity into a vault as described in Section 9.

(c) If the discharge from the cyclone or separator conveys the refuse directly to the fire boxes of boilers, the feed spout shall have an open end discharging into a suitable receiver near the furnace, so that when the furnace gets choked the refuse will fall out on the boiler room floor giving the fireman a warning, also it would prevent "back fire" when the fan blowing the refuse is stopped.

Editor's Note.—The above section applies mainly to conveyors of sawdust, cotton waste and such substances. Where considerable dust of a combustible character, see page 199, is being conveyed, the delivery direct to a boiler is strongly recommended against.

For such material, the opening in the discharge pipe would not prevent a "back fire."

(d) The air vent from the separator must not be connected to a chimney.

(e) If the air vent carries objectionable dust, as in the case of refuse, such as from grain elevators, etc., the use of a simple air washer, or other suitable filter, is recommended for eliminating the dust.

A screen shall be installed in the air vent to prevent sparks from entering.

8. SPECIAL CASES. (a) Readily ignitible stock, such as cotton, should not pass through the fan. The system should never be connected directly to picker or other hazardous machines. Systems handling such stock shall operate entirely under suction with a device such as a "condenser," or large separating chamber to discharge the stock from the pipe or conduit before it reaches the fan. Stock should be fed to system preferably by hand. Stock shall enter such a system in an upward direction and the pipe should continue upward for at least ten feet to allow any heavy substances or foreign material in the stock to drop out. If the pipe must leave the room at a lower level, a long radius inverted U may be used to obtain the necessary vertical distance.

(b) Systems using mixtures of cotton and wool which cannot be handled by condensers and which operate under fan pressure, shall discharge to non-combustible bins or boxes with outside vents through screens.

(c) Conditions which approach those favorable for explosive mixtures should be subject to a special investigation.

(d) The dust from sand-papering machines, granulators and pulverizers, buffing or polishing wheels, emery wheels and from other machines producing a very fine dust, shall have a suction system independent of the cyclone, which connects with the refuse vault.

The dust should be settled by spraying in an enclosed chamber of incombustible material, thus eliminating the hazard of the dust room. Dust from the machines may also be discharged directly into running water if suitable provision is made for its collection and removal.

(e) For mills, such as malt, cereals, sugar, celluloid, etc., it is recommended that an explosion flap be provided in a metal pipe leading outside of the building so that in case of an explosion in the mill the flap opens and the explosion spends itself outside the building.

9. VAULTS. (a) Vaults for shavings, refuse, etc., shall be located outside of building. Walls, floor and roof shall be of brick or other approved fire-resisting material.

(b) Openings, if any, between vault and boiler room should not exceed 9 square feet, and bottom of opening be not less than 6 inches above the level of boiler room floor. Openings to be located at least 8 feet from the firing door of boiler, preferably at right angles, and protected by a standard automatic fire door.

(c) Roof of vault to be provided with proper ventilating opening not less than 6 inches in diameter. As a protection from the weather this opening may be fitted with a suitable metal ventilator.

(d) Vaults shall be protected by approved automatic sprinklers. Where such protection is not available, steam jets may be installed for fire extinguishing purposes.

(e) Where dust-producing machines are used only on a small scale, the dust or refuse may, by special permission of the inspection department having jurisdiction, discharge into a substantial metal dust box, or other approved receptacle located outside the building, in lieu of a vault. The receptacle to have a hinged door or cover, which will readily open and vent a fire or explosion within.

(f) A water tank may be used in lieu of the dust box. In such cases the tank should be provided with water supply, overflow and drain pipes. On the water supply pipe a proper float-controlled valve shall be installed to maintain a constant water level. It is recommended that the end of duct be submerged into the water at least one inch.

STORAGE OF EXPLOSIVES

The storage and handling of explosives is seldom found in city risks, being usually restricted to one or two classes of occupancies. In general, the best safeguard to throw around them is to put the handling and keeping of explosives in charge of only careful men of known character, who understand the danger of the substance handled; this fitness of the employee is of vital importance.

In general, storage of explosives should not be near places of assembly, as often the panic of the people in such a place will cause more loss of life than the actual explosion.

Some fireworks, as given below, are very dangerous and should be prohibited in any place. In general, the firing off of fireworks is dangerous both to life and property, and for several years a country-wide campaign has been carried on by various organizations to have laws adopted prohibiting it; in several cities such laws have been passed and in other places or States rigid limitations have been put on the size and explosive contents of various fireworks. A more general prohibition should be made throughout the country, until only public displays, under men holding certificates of fitness, are allowed.

HANDLING AND STORAGE*

Explosives belonging to the various classes are as follows:

Class I or Forbidden Explosives

(a) Liquid nitroglycerin.

(b) High explosives containing over 60 per cent of nitroglycerin (except gelatine dynamite).

(c) High explosives having an unsatisfactory absorbent or one that permits leakage of nitroglycerin under any conditions liable to exist during transportation or storage.

(d) Nitro cellulose in a dry condition, in quantity greater than ten (10) pounds in one exterior package.

(e) Fulminate of mercury in bulk in a dry condition, and fulminates of all other metals in any condition, except as a component of manufactured articles not hereinafter forbidden.

(f) Fireworks that combine an explosive and a detonator or blasting cap.

(g) Fireworks that will ignite spontaneously when subjected to forty-eight consecutive hours in the presence of moisture to the temperature of boiling water.

(h) Firecrackers whose dimensions exceed five inches in length or three quarters of an inch in diameter, or whose explosive charges exceed forty-five grains each in weight.

(i) Toy torpedoes or caps exceeding one and one-half inches in diameter, or containing more than an average of thirty-five hundreths of a grain of explosive composition per cap.

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*Abstracted from a suggested ordinance issued by the National Board of Fire Underwriters.

(j) Fireworks that can be exploded *en masse* by a commercial detonator placed in one of the units or by the impact of a rifle bullet or otherwise.

(k) Fireworks containing a match tip or head, or similar igniting point or surface, unless each individual tip, head or similar igniting point or surface is entirely covered and securely protected from accidental contact or friction with any other surface.

Class II or Dangerous Explosives

Black Powder.
High explosives (except as described in Class I).
Blasting caps (including detonators and electric detonators).
Smokeless powder for small arms.
Wet fulminate of mercury.
Ammunition for cannon with explosive projectiles.
Explosive projectiles.
Detonating fuses.

Class III or Less Dangerous Explosives

Ammunition for cannon (except as described in Class II).
Smokeless powder for cannon.
Fireworks.

Class IV or Relatively Safe Explosives

Small arms ammunition (blank, ball or shot).
Primers.
Fuses (except as described in Class II).
Safety fuse.
Safety squibs.

DISTANCES OF FACTORIES AND MAGAZINES, FROM BUILDINGS, ETC.—All factory buildings and magazines, in which Class II explosives are had, kept or stored, must be located at distances from neighboring buildings, highways and railroads in conformity with the following quantity and distance table.

Whenever the building, highway or railroad to be protected is effectually screened from the factory building or magazine where Class II explosives are stored, either by natural features of the ground or by an efficient artificial barricade of such height that any straight line drawn from the top of any side wall of the factory building or magazine to any part of the building to be protected will pass through such intervening natural or efficient artificial barricade, and any straight line drawn from the top of any side wall of the factory building or magazine to any point twelve feet above the center of the highway or railroad to be protected will pass through such intervening natural or efficient artificial barricade the applicable distances as prescribed may be reduced one half.

Except in a dwelling, school, theatre or other place of public amusement or assembly, the following storage is permitted:

(a) One second class magazine containing not more than fifty pounds of explosive if placed on wheels and located not more than ten feet from, on the same floor with, and directly opposite to the entrance on the floor nearest the street level.

(b) One second class magazine containing not more than one thousand blasting caps, if placed on wheels and located on the floor nearest the street level.

Magazines in which Class II explosives may be kept or stored must be constructed as follows:

(a) Magazines of the first class are those containing explosives in amount exceeding fifty pounds. They shall be constructed of brick, concrete, iron

QUANTITY AND DISTANCE TABLE

Column 1				Column 2	Column 3	Column 4
Quantity that May be Kept or Stored from Nearest Building, Highway or Railroad				Distance from Nearest Building	Distance from Nearest Railway	Distance from Nearest Highway
Blasting and Electric Blasting Caps		Other Explosives				
Number Over	Number Not Over	Pounds Over	Pounds Not Over	Feet	Feet	Feet
1,000*	5,000			30	20	10
5,000	10,000			60	40	20
10,000	20,000			120	70	35
20,000	25,000		50*	145	90	45
25,000	50,000	50	100	240	140	70
50,000	100,000	100	200	360	220	110
100,000	150,000	200	300	520	310	150
150,000	200,000	300	400	640	380	190
200,000	250,000	400	500	720	430	220
250,000	300,000	500	600	800	480	240
300,000	350,000	600	700	860	520	260
350,000	400,000	700	800	920	550	280
400,000	450,000	800	900	980	590	300
450,000	500,000	900	1,000	1,020	610	310
500,000	750,000	1,000	1,500	1,060	640	320
750,000	1,000,000	1,500	2,000	1,200	720	360
1,000,000	1,500,000	2,000	3,000	1,300	780	390
1,500,000	2,000,000	3,000	4,000	1,420	850	420
2,000,000	2,500,000	4,000	5,000	1,500	900	450
2,500,000	3,000,000	5,000	6,000	1,560	940	470
3,000,000	3,500,000	6,000	7,000	1,610	970	490
3,500,000	4,000,000	7,000	8,000	1,660	1,000	500
4,000,000	4,500,000	8,000	9,000	1,700	1,020	510
4,500,000	5,000,000	9,000	10,000	1,740	1,040	520
5,000,000	7,500,000	10,000	15,000	1,780	1,070	530
7,500,000	10,000,000	15,000	20,000	1,950	1,170	580
10,000,000	12,500,000	20,000	25,000	2,110	1,270	630
12,500,000	15,000,000	25,000	30,000	2,260	1,360	680
15,000,000	17,500,000	30,000	35,000	2,410	1,450	720
17,500,000	20,000,000	35,000	40,000	2,550	1,530	760
....	....	40,000	45,000	2,680	1,610	800
....	....	45,000	50,000	2,800	1,680	840
....	....	50,000	55,000	2,920	1,750	880
....	....	55,000	60,000	3,030	1,820	910
....	....	60,000	65,000	3,130	1,880	940
....	....	65,000	70,000	3,220	1,940	970
....	....	70,000	75,000	3,310	1,990	1,000
....	....	75,000	80,000	3,390	2,040	1,020
....	....	80,000	85,000	3,460	2,080	1,040
....	....	85,000	90,000	3,520	2,120	1,060
....	....	90,000	95,000	3,580	2,150	1,080
....	....	95,000	100,000	3,630	2,180	1,090
....	....	100,000	125,000	3,670	2,200	1,100
....	....	125,000	150,000	3,800	2,280	1,140
....	....	150,000	175,000	3,930	2,360	1,180
....	....	175,000	200,000	4,060	2,440	1,220
....	....	200,000	225,000	4,190	2,520	1,260
....	....	225,000	250,000	4,310	2,590	1,300
....	....	250,000	275,000	4,430	2,660	1,340
....	....	275,000	300,000	4,550	2,730	1,380

* May be kept in second class magazines inside buildings.

or wood covered with iron, or other fireproof material having bullet resisting qualities, and shall have no openings except for ventilation and entrance. The doors of such magazines must at all times be kept closed and locked, except when necessarily opened for the purpose of storing or removing explosives therein or therefrom, by persons lawfully entitled to enter the same. Every such magazine shall have sufficient openings for ventilation thereof, which must be screened in such manner as to prevent the entrance of sparks of fire through the same. Upon each side and each end of such a magazine, or if barricaded with an artificial barricade then upon its barricade, there shall at all times be kept conspicuously posted a sign, with the words, "EXPLOSIVES—DANGEROUS," legibly printed thereon in letters not less than six inches high. No matches or fire of any kind shall at any time be permitted in such magazine. Magazines in which more than fifty pounds of explosives are kept or stored must be detached from other structures. The total amount of Class II explosives in any two or more magazines, which are located within two hundred feet of each other, must be considered in determining the lawful distances for such magazines to be from buildings, highways or railroads.

(b) Magazines of the second class are those containing explosives in amount not exceeding fifty pounds. They shall be made of fireproof material, or wood covered with sheet iron, and except when necessarily opened for use by authorized persons, shall at all times be kept securely locked. Upon each such magazine there shall at all times be kept conspicuously posted a sign, with the words, "EXPLOSIVES—DANGEROUS," legibly printed thereon, and not more than two such magazines shall be had or kept in any building.

REGULATIONS FOR MAGAZINES.—It shall be unlawful to place, keep or store any blasting caps or detonators of any kind in the same magazine together with explosives.

All magazines must be kept clean and free from grit, paper, rubbish and empty packages.

All magazines must be kept locked except when being inspected or when explosives are being placed therein or removed therefrom.

When any kind of explosive is removed from the magazine, the oldest of that particular kind must always be taken, and it shall be the duty of the magazine keeper to see that this is done.

Packages of explosives in a magazine must be neatly piled in such a way that all of them may be easily examined, and packages of high explosives must always be placed right side up.

It shall be unlawful for any person to cap a cartridge within a radius of fifty feet of a magazine, or in any case to cap more cartridges than necessary for immediate use.

No artificial light shall be used in magazines except portable electric safety battery lamps.

CHEMICAL FIRE AND EXPLOSION RISKS

In order to form an idea of the degree of fire or explosion risk attaching to establishments it is necessary to investigate:

1. The danger each of the raw materials is capable of producing during storage or while in use;
2. The same characteristic of the intermediate and final products;
3. The various processes employed: firing, nitrating, oxidizing, reducing (with hydrogen), impregnating, burning, briquetting, carburetting, carbonizing, kilning, drying, fulminating, gasification, lacquering, refining, distilling, subliming, vulcanizing, charring, calcining, incinerating, etc.;
4. The progress of the different operations, whether turbulent, accompanied by the formation of dangerous by-products and waste products, or the liberation of gas, vapor, or dust;
5. The treatment, purification, or storage of waste products or spent raw materials, with a view to their use over again (recovery or revivification);
6. The working temperatures during the various stages of operations.

The degrees of fire risk always differ and can only be accurately defined by a careful examination.

Substances of different kinds must not be stored together indiscriminately; but due regard must be paid to their mutual compatibility. For instance, the substances mentioned in the following list may cause outbreaks of fire if stored in contact with one another. For the sake of brevity only one example is given (in the principal list) in the case of groups of similar materials, thus:

Organic substances comprise all kinds of coal, peat, flour, starch, sugar, herbs, fruit, seeds, bran, grist, chaff, straw, concentrated fodder, artificial fertilizers (except those of a purely mineral nature), wood, cork, horn, paper, millboard, rags, fibres, textiles, wool, silk, cotton, flax, hemp, and leather.

Dusty substances: All pulverulent materials that readily form clouds of dust: like flour, lampblack, bronze powders, all kinds of fibrous waste, shearing fluff.

Dangerous liquids: All liquids that, at the ordinary temperature, liberate inflammable vapors which form explosive mixtures with air, namely, carbon disulphide, ether, acetone, alcohol, wood spirit, lacquers, varnishes, benzol, petroleum spirit, illuminating oils.

Carriers of Oxygen: All substances that are chemically highly charged with oxygen or ozone and will part with this when a favorable opportunity occurs and hence exhibit the same dangerous properties as oxygen. When the liberation of oxygen by these compounds is effected in an atmosphere of inflammable gases or vapors, or in direct contact with organic substances, like resins, ethereal oils, or mineral oils, and the temperature is merely slightly elevated, an immediate ignition of these substances may occur, if the circumstances are favorable. Certain carriers of oxygen will ignite organic substances even at the ordinary temperature.

The most important carriers of oxygen are enumerated below, the temperatures or other conditions at which they liberate the oxygen, and therefore become dangerous, being also mentioned.

Perchloric acid, at the slightest opportunity, even during storage, with violent explosion.

Permanganic acid, on gentle warming, any organic matter present being thereby ignited.

Potassium permanganate, in a warmed solution; dry, at 240° C.; when mixed with sulphuric acid, it will ignite all inflammable gases, vapors, ethers, etc. The dry salt tends to ignite spontaneously when suffused with glycerin.

Iodic acid and periodic acid, at 300° C.; at the ordinary temperature in presence of organic matter.

Persulphuric acid, analogous to hydrogen peroxide.

Potassium or ammonium persulphate, at 100° C.; at the ordinary temperature when dissolved in water.

Potassium perselenate liberates oxygen when the solution is warmed.

Chloric acid ignites organic matter on simple contact at ordinary temperature.

Chromic anhydride at 250° C. detonates and ignites organic substances when suffused with alcohol.

Chlorates liberate oxygen in an explosive manner under the influence of friction, shock, concussion, or heat (about 800° F.). When mixed with potassium cyanide, oxygen is immediately disengaged with explosion.

Nitrogen pentoxide (nitric anhydride), with violence at 50° C.

Sulphur heptoxide disengages oxygen very violently during storage, when dissolved in water or warmed.

Bismuth pentoxide (bismuthic anhydride), when heated, or treated with strong acids.

Calcium hypochlorite ("chloride of lime"), when gently warmed or exposed to direct sunlight.

The following substances may be classed as carriers of oxygen that liberate that element at high temperatures only:

Barium, lead, manganese, potassium and sodium peroxides; potassium perchlorates; all nitrites; ozone; oil of turpentine, and colophony.

Disinfectants.—The carriers of oxygen are largely used as disinfectants, for the destruction of organic matter, and in bleaching. For these purposes preference is mainly given to hydrogen peroxide (which is explosive) and sodium peroxide. When sprayed, or in the form of vapor and mixed with dust, carriers of oxygen or ozone augment the danger of explosion by increasing the inflammability, heat of combustion, and explosive power of the dust.

Dangerous Combinations

The substances in italics should not be stored with those mentioned after them in each section of the following list:

Organic Substances, with nitric acid, carriers of oxygen, ozone, peracids, picrates, chlorates, liquid air, fulminates, fats or oils.

Lampblack or Carbonaceous Substances, with fats, oils, sulphur, metallic sulphides, or carriers of oxygen.

Metals in Powder, Bronzes, with damp substances, water, dusty materials, mineral acids, ethereal or fatty oils, oil of turpentine, carriers of oxygen, ozone, liquid air, peracids, or flowers of sulphur.

Peracids, with organic substances, sulphur, metallic powders, bronzes, carbon, or dangerous liquids.

Resins, Turpentine, Ethereal Oils, with iodine or chlorine, mineral acids, carriers of oxygen, or dangerous liquids.

Carriers of Oxygen, Liquefied Oxygen, Ozone, with fulminates, chlorates, organic substances, picrates, bronzes, metallic powders, dangerous liquids, carbon, lampblack, resins, phosphorus, sulphur, sulphuretted hydrogen, nitric acid, or dusty substances.

Dangerous Liquids, with carriers of oxygen, ozone, liquefied oxygen, oil of turpentine, ethereal oils or peracids.

Carbides and Quicklime, with water, damp substances, or acids of any kind.

Strong Nitric Acid, with oil of turpentine, hydriodic acid, organic substances, sulphuretted hydrogen, carriers of oxygen, ozone, carbides, metallic powders, bronzes, strong sulphuric acid, fulminates, picrates, or chlorates.

Strong Sulphuric Acid, with strong nitric acid, saltpetre, substances impregnated with saltpetre, metallic powders, bronzes, carbides, picrates, fulminates, or chlorates.

Carbon Disulphide, with carriers of oxygen, ozone, or liquefied oxygen.

Fulminates, Picrates, Chlorates, with mineral acids, organic substances, sulphur, carriers of oxygen, ozone, or liquefied oxygen.

Dusty Materials, with metallic powders, bronzes, carriers of oxygen, ozone, or liquefied oxygen.

Sulphur, Metallic Sulphides, with carbon, lampblack, fats, oils, chlorates, or phosphates.

Water (Solutions), Damp Substances, with quicklime, carbides, metallic powders, bronzes, light metals.

Phosphorus, with chlorates, carriers of oxygen, ozone, or sulphur.

Nitrates and Substances Impregnated with Saltpetre, with sulphuric acid.

Fats, Oils, with organic substances, lampblack, carbon, metallic sulphides, or pyrites.

Materials which Should be Isolated.—The following substances should be isolated during storage: all those spontaneously igniting or explosive; all firework charges, nitrated cellulose, fulminates, detonating compounds, chlorates, picrates, peracids, igniting pellets, gunpowders, metallic nitrides, nitrogen iodide, chloride, fluoride, and bromide, the dangerous peroxides (e. g., hydrogen peroxide and potassium peroxide), liquefied gases, acids and phosphorus.

SPONTANEOUS COMBUSTION

The processes and conditions which may incite to spontaneous heating or spontaneous ignition, taken in the widest sense, according to Von Schwartz, are:—

	Predominantly in the case of
1. Moisture	Agricultural products, fodder, manures.
2. Bacterial activity	
3. Germination	
4. Storage in large heaps	Agricultural products, coal, tobacco, oleaginous substances.
5. Protracted drying	Wood, organic substances.
6. Contained sulphur	Lampblack, coal.
7. Contained finely divided carbon	Metallic sulphides.
8. Contained fat or oil	Organic substances, fibres, colours (paint), clothing.
9. Occlusion of oxygen	Coal, etc., metals.
10. Absorption of moisture	Quicklime, potassium, sodium, carbides.
11. Fineness of division	Metals, bronzes, varieties of dust, fats, oils.
12. Recent calcination	Carbonised substances, metallic powders, metallic sulphides, lampblack.
13. Exposure to the sun	Phosphorus in fragments, oxyhydrogen gas.
14. Concentration of the sun's rays (burning glasses, lenses, glass bricks)	All readily ignitible substances.
15. Friction, pressure, shock, fall	Numerous detonating, explosive substances (spontaneous ignition being here generally modified into explosion).
16. Electricity (sparks)	Explosive vapour mixtures, dry cleaning works, resinous bodies.
17. Air	Phosphuretted hydrogen, and numerous compounds (ethyl-, methyl- and propyl-compounds), pyrophorus substances.
18. Contact with spongy metals (platinum black)	Hydrogen gas, oxyhydrogen gas, coal gas.

Periods of Development.—The examples numbered 1-9 mostly exhibit slow development (chronic spontaneous ignition), those numbered 10-14 progress with moderate rapidity; 15-18 are sudden and of explosive character (acute).

The period of development in cases of chronic spontaneous ignition may extend over two or three months; in many cases a good deal depends on the bulk of the stored mass; where this amounts to some hundreds of tons, as in the case of bran, cereals, etc., spontaneous ignition may sometimes take two to three months before becoming apparent externally.

Causes.—Many of the fires originating in warehouses are supposed to be due to spontaneous combustion resulting from the saturation of the fibre with oil from the seed, expressed by the process of baling and handling, and the numerous fires in cotton gin houses may be largely due to the ignition of cotton saturated with oil from the cotton-seed expressed during the process.

The presence of as little as 3 to 5 per cent of fat or oil may cause fibrous material to ignite spontaneously. Inasmuch as 8 to 10 per cent of oil will remain even after pressing oily or greasy fibrous material it is evident that the hazard exists until the material is thoroughly cleaned by washing or a solvent. The principal items tending to induce heating are: The porosity of the fibre, i. e., the amount of fatty or oily surface it presents to the air; the affinity of the fat or oil for oxygen; the possibility of loosing heat to or taking up heat from some outside source; the pressure under which the substance is kept, and the presence of oxygen carriers.

Mineral Oils.—The mineral oils have practically no affinity for oxygen and can therefore be used without objection for oiling fibrous materials, except when the mineral oil is impure, consisting of a heavy oil containing paraffin, and the impregnated material is hung on steam pipes, boilers, stoves, or in contact with some other warm object, or exposed to heat for some time; or when the oil is strongly contaminated with sulphur or iron sulphide, usually found in distillation products of lignite or coal.

Lubricants.—In general lubricants of animal origin (tallow, lard, train oil, neats-foot oil) have the greatest cooling effect on axles and shafts, but render the cleaning rags liable to spontaneous ignition.

Lubricants of earthly origin (petroleum, shale oil and paraffins) have the smallest cooling effect, but only become a source of danger to the cleaning waste under special circumstances.

Lubricants of vegetable origin, and of a non-drying character, stand between the other two kinds in respect of cooling properties; but are the most dangerous of all in connection with fibrous materials. The danger of spontaneous ignition may be diminished by an addition of 25-50 per cent of mineral oil, provided the mineral oil is free from paraffin and sulphur impurities.

Oils and Fats.—Because of the differences in fibrous materials and the effect that local conditions have, no exact classification of oils and fats as to their power of imparting a tendency to spontaneous ignition can be made. In general, the amount of iodine absorbed by 100 grams of fat gives a fair representation of their danger.

Vegetable Fat.	Iodine Value.	Animal Fat.	Iodine Value.
Linseed oil	170	Codliver oil	140
Hemp oil	150	Seal oil	127
Nut oil	146	Japan liver oil	120
Poppy oil	138	Goose fat	71
Olein	138	Bone fat	68
Cottonseed oil	108	Hog fat, American	62
Sesame oil	106	Hog fat, German	58
Rape oil	101	Tallow	42
Ground-nut oil	96	Mutton tallow	42
Castor oil	84	Wool fat	36
Olive oil	82	Butter fat	30
Palm oil	52		
Cocoa butter	36		
Palm kernel oil	14		
Cocoanut oil	9		

Linseed oil is therefore the most dangerous, and its danger is increased when boiled into varnish. The rancidity of oils and fats increases the danger from spontaneous heating and rancid animal fats and oils are more dangerous than pure vegetable oils.

Heat Dangerous.—The sun and heat must be carefully excluded wherever oiled fibres are in question, and suitable provision must be made to ensure cooling. Where the application of warmth is necessary to a manufacturing process, great care should be taken to accurately check the temperature by the aid of a thermometer; testing with the hand is insufficiently reliable.

Kissling found that fibres soaked with linseed oil, and exposed to direct sunlight, became heated to 266° F. in 4 hours, and afterwards took fire; sheltered from the sun's rays, the temperature did not exceed 78° F. in the same time.

Spontaneous ignition is favored by carbonization of the fibre, or the presence of carbonaceous substances, because of the increased absorptive power for oxygen, holding more of that gas in their pores.

The application of pressure increases the hazard, as the more tightly any substance is packed and compressed, the better is it enabled to retain warmth.

Prevention of Ignition.—There are no direct means of preventing spontaneous ignition in oiled fibres; impregnation with antipyrenes renders the fibres uninflammable, but not the fatty matter, since this latter cannot be impregnated, and charring will occur, even though fire be prevented.

The best preventive of the danger involved consists in the employment of good oil, free from rancidity: pure vegetable oil mixed with 20-30 per cent of pure mineral oil. Coal-tar oils cannot be recommended, owing to their irregular composition (presence of sulphur), and animal oils are better avoided.

Safeguards.—Oiled fibrous material should be kept in approved waste cans (see page 224), kept away from all sources of heat, protected from the rays of the sun, and burned or removed to a safe place every night. All operations with oiled materials should be under thorough supervision, and the temperatures carefully checked.

Storage Hazards.—Fats and vegetable and animal oils, and some of the higher grades of refined mineral oils introduce very little hazard in their storage, as the flash point is low and the danger of ignition slight. However, it must be remembered that at high temperatures, usually over 450° F., they give off vapors which take fire spontaneously when heated to about 20° F. above their temperature of formation, and these vapors may become explosive when mixed with the right proportion of air. The danger of leakage impregnating fibrous material sufficiently to cause spontaneous combustion is also a hazard to be guarded against; the use of sawdust to absorb such leakage is very unwise.

Storages of fats and oils of this character in congested districts or in the main parts of a plant are very objectionable because of the difficulty in extinguishing them when ignited from some outside cause. The containers will be ruptured by the internal pressure of the vapors liberated by heat, and the contents spread for considerable distances.

Burning Temperatures.—At the following temperatures the oils specified will go on burning:

Olive oil	at 662° F.	Linseed oil	at 662° F.
Rape oil	at 662° F.	Engine oil	at 275-[illegible]° F.
Hempseed oil	at 329° F.	Spindle oil (light)	at 505° F.
Poppy oil	at 662° F.	Spindle oil (heavy)	at 550° F.
Sesame oil	at 662° F.		

Fat Rendering.—The recovery of fat by melting (rendering) and the cooking or refining of the oils of high flash point are dangerous if direct fire heat is employed; superheating, ebullition attended by decomposition, or the formation of inflammable vapors may easily lead to an outbreak of fire. The danger is diminished, to a certain extent, by the use of steam heat.

The dangerous vapors liberated must be rendered harmless by conducting them into a fire, where they will be consumed, or by condensation or proper ventilation to the outside air; as the vapors are explosive when under pressure the pipes and vessels used in a condensing system must be fitted with safety valves.

Use of Solvents.—The risks are far greater in works where the fat and oils are extracted with solvents instead of by pressing.

In addition to ether, naphtha, carbon-disulphide and alcohol, all very dangerous solvents, there are other less dangerous, and even harmless, such as carbon tetrachloride, ammonia, chloroform, benzol soaps and oxgall, but unfortunately their solvent power is relatively insignificant, and they are seldom used.

Fat Extraction.—The apparatus used in extracting fat is nowadays of very perfect construction, as indeed is essential in view of the dangerous materials employed; but though they offer a certain guarantee of safety, the claims of absolute security, sometimes preferred by the makers, are not in harmony with truth. In addition to the general requirements given on pages 137 to 145 in regard to the handling of the readily inflammable solvents, it must be expressly prescribed that no pressure must be allowed to obtain within the extraction apparatus, even when the solvents are in ebullition, since any appreciable pressure on the vapor of the solvents increases the explosibility and the danger of a violent explosion.

The apparatus must be so arranged that the separation of the raw material, solvent and fat must be effected in a single train of operations within the apparatus, and without any part of the latter or its appurtenances requiring to be opened.

Charred Wood.—Wood which has been for a length of time in contact with pipes containing hot water or steam seems to be reduced gradually to a condition favoring spontaneous ignition. The destruction of the English House of Parliament and many other fires have been attributed to this cause.

From statistics as to fires in dry-kilns and dry-rooms it appears evident that wood subjected continuously to heat for a given length of time gets into a condition where it ignites spontaneously; this indicates the necessity of discontinuing the use of wood in rooms subject to high temperatures.

In newer wooden structures the most dangerous are those composed of wood that still continues to exude resin, which chars more easily than the wood itself.

Pipes Should be Insulated.—The best way to prevent injury to wood and other organic substances by the influence of pipes, etc., conveying steam, hot gases and hot liquids. is by using some good insulating material (non-conductor of heat).

Certain paints—lead paints and asphaltum—applied to steam pipes increase the loss of heat as much as 25 per cent; the pipes become hotter, the radiation of heat more extensive, and the danger correspondingly increased.

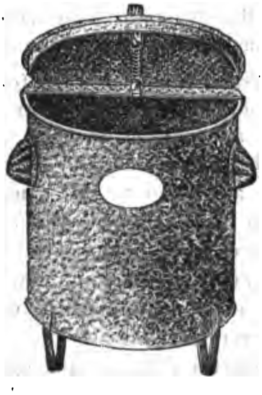
Waste Cans*

1. SIZE.—To be not smaller than 11 inches diameter and 11 inches deep inside, nor larger than 22 x 25 inches inside, if used for oily waste. Inside diameter to be not less than 90 per cent of height excluding legs. It is desirable to use a number of smaller cans, rather than fewer large ones.

2. BODY.—For cans 11 x 11 inches inside, not less than No. 26 gauge, U. S. Standard (.0187 inch), galvanized iron or steel and increase thickness one number in gauge for each 3-inch increase in diameter.

3. LEGS.—To be made of band iron not less than 12 gauge, U. S. Standard (.1093 inch), ¾-inch wide, riveted to side and bottom of can, two rivets at each end, and not less than 3 inches high for cans 11 x 11 inches, three legs on each can; for larger sizes, not more than 4 inches high, gauge and width increased in proportion to size of can, using 11 x 11 inches as base.

4. COVER.—To be in two sections, width of one section to be equal to about one-third the diameter and riveted to the can with the movable lid permanently and freely hinged to the rigid section without soldering, and to have a device to prevent opening more than a 60 degree angle from horizontal and weighted sufficiently to make closure positive and automatic. Iron to be of at least two numbers heavier than the body, lid to extend beyond the body of the can, finished with a hemmed or wired edge and made rigid by two strips of band iron ⅛ x 1 inch, riveted inside lengthwise and outside crosswise respectively in the middle of the lid, the outer end bent upward at an angle of about 45 degrees.



SELF-CLOSING OILY WASTE CAN.

5. HANDLES.—To be riveted to the rigid portion of the cover and preferably made from band iron ⅛ x 1 inch bent to form a stop for the lid. Side handles must be supplied on cans larger in diameter than 16 inches.

6. Construction.—Can to be assembled with all seams lock-jointed or riveted and attachments riveted on. Body of can to be wired at top with wire not smaller than No. 9 for can 11 x 11 inches, proportionally heavier for larger cans, or finished with band iron of equivalent strength.

7. Marking.—Each can to be plainly and permanently marked with its trade-name and the name, initials or trade-mark of the manufacturer.

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*As recommended by the National Board of Fire Underwriters.

NOTE.—Waste cans are required for all oily waste, and recommended for clean waste.

It should be the practice to empty oily waste cans and burn the contents every evening. Oily waste should not be allowed to remain in cans over night.

Ash Cans and Refuse Barrels*

8. Size.—To be determined by necessities of risk, but not smaller than 12 x 12 inches.

9. Body.—Not less than No. 24 gauge, U. S. Standard (.025 inch), for average size of 15 x 26 inches used for general purposes, and No. 20 (.0375 inch) for bottom. To increase one number in thickness for each 3-inch increase in diameter.

10. Flanges.—To be reinforced top and bottom by flanges riveted on, of not less than No. 12 (.109 inch) iron. Flange at bottom to be of height to insure air space of 2 inches between lowest point of bottom and the floor.

Flange at bottom to be perforated at intervals with ½-inch holes to vent the space formed by flange.

To be reinforced by vertical ribs, made of angles, channels, sheet metal bosses, corrugated or strap iron. If made 50 per cent heavier, reinforcement not required.

11. Handles.—To be of wrought or malleable iron, securely riveted to can.

12. Covers.—Must have covers, to be loosely fitting over outside of can to take up irregularity of top of can due to service, and to have flange 2 inches deep.

13. Engineers' Ash Cans.—Should be of not less than No. 16 (.0625 inch) iron, and flanges not less than ¼-inch thick, and bottom flange to be of such width as to admit of 2 inches clear air space, and to be ventilated.

14. Marking.—Each can must be plainly and permanently marked with its trade-name and the name, initials or trade-mark of the manufacturer.

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*As recommended by the National Board of Fire Underwriters.

CONSTRUCTION

PLANNING

In the planning of building operations the prevailing thought is generally devoted to the economic conditions. Plans are often formulated which may seem economical from a certain standpoint, but when the many conditions involved in building operations are considered that which may first appear as economy is in reality false economy; true economy involves not only the needs of the structure for which purpose it is intended, but in making the best use of the available building materials as well as properly determining the best type of construction, suitable for the location of the structure.

Alterations or additions of any magnitude require the same forethought as new structures and by properly studying the conditions the property as a whole would be improved.

The planning of structures should involve not only their present requirements but the possibility of future extensions.

The defence against fire should be formulated from the beginning in the planning of all structures, it is, therefore necessary to thoroughly consider the nature of all surrounding buildings or the possibility of future buildings being erected on adjacent ground; such conditions will determine the selection of proper materials for wall or cornice construction, as well as planning the proper window and door openings and the proper protection of the same; these features govern the exposure charges of the Fire Insurance Underwriters, and unless provision is made in the plans for the exposure conditions, future expense arises not only in correcting structural defects, but in the continued additional expense in insurance premiums.

In planning manufacturing properties time is well spent in studying the arrangement of the processes to be incorporated in the structures in order to prevent the principal hazards from endangering the main values. There is hardly any step in the designing of a structure of any kind which does not have a certain bearing, direct or indirect, from a fire protective standpoint. It is possible to design and construct any class of structure in a thoroughly economic manner if proper study is exercised in the planning and if provision is made for the fire protective features.

Accept the evidences of the destruction that is continually taking place from fire in all classes of structures; plan the structure in such a manner that it will be a permanent investment, and arrange and protect the property in such a manner that fire can cause only a minimum of damage, remembering that fire resisting structures also resist depreciation.

Secure the rates of insurance on various kinds of structures before selecting your building materials or perfecting the plans. Faulty planning and construction are directly responsible for the enormous fire waste, and it has been repeatedly demonstrated that with the proper planning of the constructive features the ultimate costs are less than in buildings of inferior construction.

Absolute fireproof buildings do not exist, but fire resisting buildings do, and the amount of resistance depends on the intensity and duration of a fire and on the materials entering into the construction.

The general layout of the building and proper insulation of certain parts, such as the stairs, elevators and portions likely to admit a draught to adjacent stories are features which should receive special study in planning structures.

Fire cut-offs should receive special attention in planning, and be arranged to prevent the spread of fires over large areas. Metal structural work should be properly protected against fire and a careful study should be made of the proper materials to be used for this purpose.

Those conditions which are conducive to cleanliness and the proper planning to assist in maintaining this feature are equally important from a commercial standpoint as well as a safeguard against fire.

As the fire protective devices differ in various classes of structures it is important to seek the co-operation of the insurance underwriters. If owners, architects and engineers would confer with the insurance organizations before their plans have reached an advanced stage much valuable information would be given which would not only assist in securing improved construction and fire protection, but reduce the cost of fire insurance which is a direct yearly tax not only to the owner but the occupants.

It is the duty of the property owner to protect the life and limb of the public, whether such properties be used for churches, schools, places of public assembly, tenements, mercantile buildings or factories, and only such persons who have made a study of the science of the prevention of loss by fire in connection with the other requirements of their profession should be entrusted with the planning of such structures.

DEFECTIVE CONSTRUCTION

Nothing develops structural defects as much as fire, and as all classes of structures have been subjected to this test, comparisons between good and bad types of construction can readily be based on actual facts. Some types of construction may be judged defective for certain classes of buildings owing to the surroundings, nature of the occupancy, and the height of the structure, whereas the same type of construction, under different conditions, would not be called defective owing to the nature of the occupancy, the possibility of no danger from the surroundings and adequate fire protective devices.

Any class of structure which admits of rapid combustion or deterioration under fire or the elements, is defective, likewise a structure in which fire cannot be fought to advantage, is defective.

Common defects in structures are often latent from the time the building has been under construction and if discovered at all it is generally too late to rectify the errors, as the damage occasioned by fire is of such a nature that the structure is ruined beyond repair. Structural defects are to be found in all portions of buildings; any local defects may subject the entire structure to ruin.

Defective Foundations.—The stability of a structure is primarily dependent upon its foundations, and as the foundations generally exist at such locations where it is difficult to regularly examine the conditions from time to time it is of vital importance to arrange for the proper determination of the sustaining strength of the soils and the proper type of foundation planning to suit this condition. It should always be considered that fire under certain conditions can exist in out of the way places, where it is difficult or impossible to reach the seat of fire, by hose streams, or chemicals. It is therefore important to use only such structural materials as will offer the maximum resistance to fire, as well as other depreciable influences. Foundations not only include the supports of the structure itself, but of the internal appurtenances, such as boilers, ovens, fireplaces, chimneys, heating apparatus, and various forms of machinery which by unequal settlement or disintegration of the materials, lead to unobserved open joints or cracks through which sparks or hot gases may pass and communicate fire to the contents of the building; or as frequently happens, back of wood furring which is used for plastering or interior finish.

Hot bearings of machinery frequently arise from settlement caused by defective foundations. Improper footings, supports or foundations for superimposed loads, such as merchandise, special machinery, chimneys, water tanks or conditions due to periodical vibration are conducive to the destructive influences of deterioration and fire. Columns are often thrown out of alignment, important structural members are sheared or deprived of proper bearings, the result being that a light shock or fire of small magnitude would tend to wreck the entire structure.

Stonework.—The use of limestone, bluestone and granite should be avoided in connection with supporting columns, bond stones or lintels, as in case of fire and the application of water, stonework often, no matter how substantially built, rapidly disintegrates and wrecks the entire structure. Granite piers have been known to disintegrate into the consistency of sand. Stone lintels should never be used over large or important door or window openings.

Chimneys and Flues.—The defective flue is especially disastrous in dwellings, as the plastering of the interior walls or partitions prevents the observation of the common defects. Flues built in connection with walls are likely to become defective, as the natural tendency of the wall is to settle, owing to the unequal loading on the foundations, the result being that the wall will crack from flue to joist and at the point of contact, probably the crack will fill with soot, and in time there is a likelihood of a spark igniting the soot in the crack, the fire in turn finding its way to a dried out joist or timber which is susceptible to ignition. In such thoroughly concealed spaces the spark of fire will glow into a flame, which forces its way along the joist or back of the furring, burning there until it bursts forth in a number of places, causing a destructive fire. Poor masonry work, thin walls, lack of properly mixed mortar and open joints are common defects. Flues arranged on corbels formed in walls are especially subject to cracking. The running of floor timbers into flue walls or arranging such timbers directly against flue walls is bad. Negligence in not providing masonry trimmer arches for hearths, fireplaces or grates is a common defect and is often found. It is very important to safeguard the header and trimmer timbers adjacent to all flues, stacks, fireplaces, or where there is any danger from heat or sparks.

Stovepipes.—As stovepipes frequently cause fires, every precaution should be taken to provide for the proper support of stovepipes, which should be substantially made. The joints of stovepipes should be thoroughly riveted and no solder should be used. Long stovepipes are dangerous. Care should be exercised in avoiding open joints where stovepipes enter chimneys as leaks at such points are dangerous. Stovepipes should not be run through combustible walls, partitions, floors, ceilings or roofs. Where such conditions cannot be overcome, double metal thimbles with air spaces around them of at least one inch should be provided.

Steam Pipes in contact with woodwork cause the wood to carbonize and it is then subject to rapid combustion. Without proper metal collars, there is danger from dirt, rags, etc., accumulating in the exposed space around the pipe, which is further conducive to fire.

Furnaces in low basements where the top of furnace is close to the joists or other woodwork are especially dangerous. This comment will also apply to stoves where there is always the possibility of overheating, exposing such woodwork to rapid combustion. Proper protection should be provided with incombustible materials, which at the same time will provide suitable insulation against radiated heat. Or, preferably, the woodwork should be entirely eliminated in the vicinity of stoves, whether at sides, back or at the hearth.

Hollow spaces and wood furring are dangerous as the spaces form flues through which fire rapidly flashes, and it is very difficult to reach the seat of fire with fire protective apparatus. Fire stops should be provided at all floors and metal or non-combustible furring should be used instead of wood.

Hollow and concealed spaces in floors and walls, especially in buildings constructed of wood, are dangerous, as not only do such spaces harbor vermin, but form many flues or passages open for the communication of fire through all portions of the building. Fire in such spaces is difficult to locate and hard to extinguish. Fires in steep roof with concealed spaces therein are especially difficult to fight.

Boxed cornices are dangerous, as they admit of fire communicating to all portions of the roof, the hollow spaces making it difficult to locate the seat of fire as well as to extinguish it.

Inaccessible spaces under floors are responsible for the rapid spread of fire, as it is impossible to direct hose streams to advantage in such spaces. A frequent custom is to build floors some distance above the ground level, supporting the joists or floor beams on piers and girders. Cracks or openings are likely to exist in the floor allowing a draught to convey fire through and under the floor which will continue to burn often unobserved until the entire floor is wrecked. Such spaces harbor vermin, filth and rubbish all of which are conducive to fire hazard, and the existence of such spaces is also favorable to dry rot or rapid deterioration of the constructive timbers. The effect of a small fire under such conditions is often disastrous. It is preferable from an economic standpoint alone to avoid the existence of such spaces under all floors and platforms.

Dry Rot.—This condition should ever be guarded against in all forms of timber construction. Green timber is especially subject to this result of fermentation. Seasoned timber is affected by the lack of proper circulation of air, and great care should be taken to secure ventilation around wood work, where beams enter walls. The use of plaster of paris, cement and similar materials which are absorbents of moisture should be guarded against in connection with wood work, and such materials should never be brought in direct contact with wood work. Lime mortar is considered preferable.

Built up beams or girders with spaces between the timbers, are especially subject to the destructive action of fire. Should fire gain headway in such inaccessible spaces, it is impossible to reach the seat of the fire by sprinklers, or hose streams, especially if the hose streams are directed from the outside of the building.

Exposed Structural Metal Work.—In buildings or rooms where the contents are of a combustible nature, exposed structural metal work constitutes a structural defect, as steel or wrought iron when subject to a mild fire rapidly fail by buckling, expansion or bending. Steel begins to lose its strength at a temperature of 500 degrees.

The use of metal rods in connection with timber construction is a serious defect, especially when used with wood girders. A common method of securing long spans in wood girders is to strengthen the timbers with truss rods; spans of from thirty-five to forty feet are frequently planned. The timbers under such conditions without the reinforcing truss rods would ordinarily support but a fractional portion of the load. The main carrying capacity being imposed on the metal rods, any failure of the rods would naturally result in the destruction of the entire girder. There are a number of ways in which fire can wreck such a girder. The primary result of fire on such construction is the expansion of the rods, and as no provision can be made in this form of construction for eliminating expansion of the metal, the rods in question readily detach themselves from the struts, posts or chairs leaving the timbers unsupported. The results of deflection and vibration are readily manifested in such types of construction, and unforeseen weaknesses can develop at the joints or threaded ends of the rods which when subjected to the action of fire rapidly lead to the destruction of the entire girder.

The use of iron rods for the support of hanging galleries or intermediate floors should be avoided.

Supporting and Cut-Off Walls.—A defect frequently existing in such walls is the lack of proper structural material at certain places to retard the progress of fire from one building to another. Poor mortar joints are often responsible for the communication of fire through intended fire stops. Beams and joist are often extended into cut-off walls in such a manner that little or no space exists between the ends of timbers on either side of the wall, with a result that the burning or falling timbers allow direct communication for fire to the opposite side of the wall. This condition frequently exists at roofs where extra wood strips or timbers are often inserted into so-called fire walls for the support of roofing or arranging flashings.

Wood girders over door openings in division walls should be avoided; the nearer the division wall is self-sustaining without the introduction of beams or supporting members built into the same the more substantial and effective the wall becomes as a fire retardant.

Open elevator wells, stairways and belt holes through floors are structural defects in all classes of buildings irrespective of the type of construction. With such features the entire building is subject to draughts and the progress of fire cannot be confined to a limited area; fire under such conditions will quickly flash from story to story and soon be beyond control. Such conditions are also conducive to the so-called dreaded back draft or smoke explosions, which are due to the subsequent ignition of the volumes of suspended carbon and gases arising through the building.

Varnished woodwork or hardwood finish is undesirable from a fire protective standpoint, as fire will rapidly flash over surfaces thus treated. Mills, offices and places of public assembly should be free from such conditions. Woodwork thus finished is often supported by wood furring with the existence of hollow spaces. This type of construction admits of the rapid progress of fire, and such conditions have defied the efforts of fire departments to save life and property.

Sheet metal nailed to woodwork for protection of the wood against fire gives a false sense of security, as the metal conveys the heat to its wood backing and ignition of the latter would be hidden by the metal facing. Nails readily pull out and fire can work through the joints or cracks and ignite the woodwork. Fire under such conditions is difficult to fight. Metal work is not an insulator against heat and anything but a short flash fire is liable to cause the woodwork to ignite.

Where it is desired to protect exposed woodwork, only such materials should be used as are incombustible and will provide insulation against heat.

Quick Burning Construction.—Manufacturing and mercantile buildings, schools, or places of public assembly should never be constructed with light floor or roof timbers. A frequent custom is to arrange light joists or rafters from two to three inches in width spaced from twelve to eighteen inches apart. This form of construction admits of serious fire loss due to the numerous exposed surfaces to which a fire could readily communicate. The spaces between these joists act as flues in which fire cannot readily be extinguished especially by outside hose streams, the result being the seat of fire cannot be reached, and if fires under such conditions are not extinguished in their incipiency the results are disastrous. The sheathing of the underside of joist with wood or plaster aggravates the above conditions.

Where timber enters into building construction it is preferable to arrange the same in heavy solid masses in order to expose the least number of corners or projections to fire.

Misplaced Fire Escapes.—It is a common error to locate fire escapes in such a manner that they are exposed to the action of fire bursting from windows, and many fire escapes are so arranged that flames coming from a single window along the line of fire escape cuts off every chance for those above. Correctly placed a fire escape should be upon a blind wall wherever possible, with approaches or bridges at each story running to and opening upon it. This feature should receive particular consideration in factory buildings, schools and places of public assembly. The laws of some municipalities require smoke proof fire towers which are the correct solution of the problem of safe exits.

Exposure Conditions.—In order to overcome structural defects which may develop from outside sources, the exteriors of structures should be constructed with due consideration of the nature of the surroundings. Fire may enter through exterior doors and windows or skylights unless these features are properly designed. Wood or combustible cornices readily communicate fire from exterior sources and they should never be designed for structures to be erected in congested districts. The construction of bay windows or windows with large glass areas should be avoided where there is danger of fire communicating from the exterior. Large wood cupolas, wood ventilators or monitors should not be arranged on roofs where fire could communicate to the same. The use of cut stone work and ornamental terra cotta should be avoided in built-up districts or where fire could damage the same. Shingle or other combustible roofs are frequently found where external fires can readily communicate to, and destroy property. Such roofs should not be used after the completion of the building, in which event such defects as above outlined cannot be overcome or protected against fire after the completion of the building, in which even such defects form a fixed charge upon the property and contents thereof as long as the structure exists.

Conditions conducive to rapid deterioration constitute structural defects which should be guarded against in the selection of building materials or the assembling of the same.

Climatic conditions have a direct effect on materials and should be considered. The action of moisture, gases, steam, and radiated heat from furnaces or boilers have injurious effects on structures which are often overlooked, and as a result serious conditions are likely to ensue, especially in types of construction where thorough periodical examination of the structural members is not feasible.

It frequently develops that serious results ensue from the deterioration or disintegration of apparently minor structural members; this especially applies to structural metal works which is susceptible to rapid deterioration if not properly protected. Wrought iron and steel are liable to be thoroughly consumed by rust and the action of this disintegrating influence is first apparent at points where two surfaces come together as in joints in Z or angle columns. It is therefore important to provide for the avoidance of concealed spaces in structural metal work and to design such members in such a manner as to guard against the promotion of rust and its concealment. The covering of metal work should be of such a nature as will protect the same from rust; the painting of iron preserves it only as long as the oil of the paint lasts. The protection of metal work should not be attempted with such materials as absorb moisture. Steam pipes should never be placed and concealed near wrought iron or steel columns, as escaping steam or condensation is liable to cause and hasten rusting. Cast iron should not be used for beams or lintels as it is brittle and will not withstand shock or vibration. When used in columns defects in the castings should be guarded against, as frequently the castings are thin on one side and thick on the other which is due to the floating of the cores in the moulds. While cast iron is not as susceptible to rust as steel and wrought iron, the action of fire thereon should be guarded against by proper fireproofing materials.

Defective Fire Doors and Fire Shutters.—Fire doors and shutters are subject to rapid deterioration if not properly installed

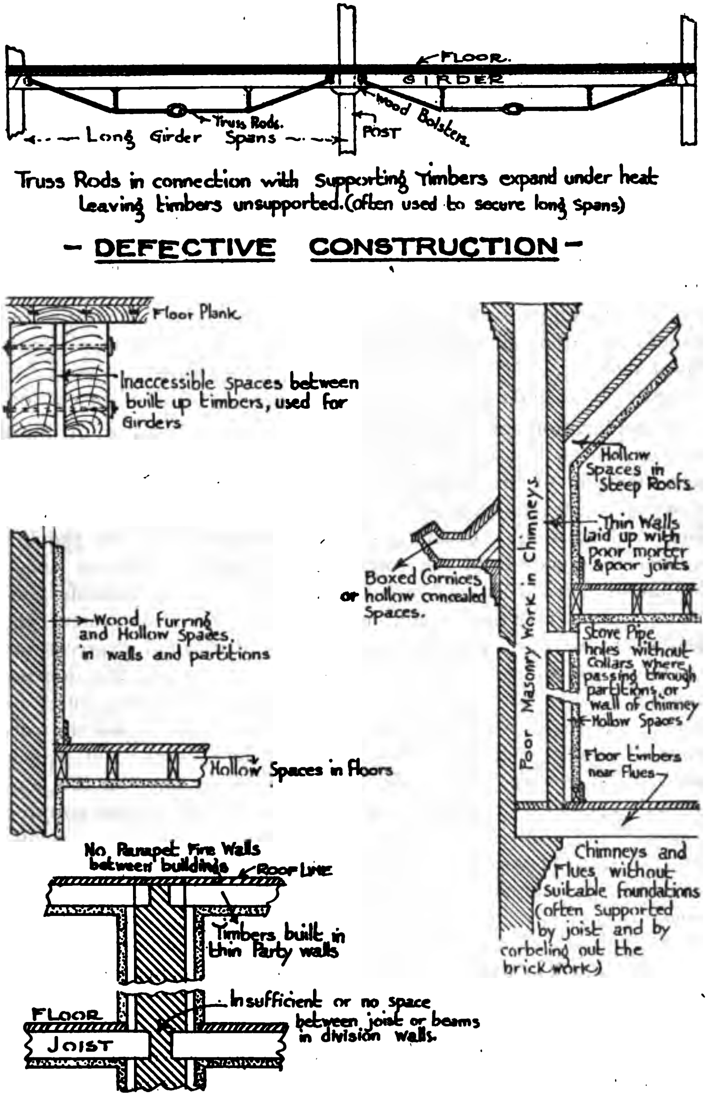

FLOOR.
GIRDER
Wood Bolster
POST
Truss Rods.
Long Girder Spans
Truss Rods in connection with supporting Timbers expand under heat leaving timbers unsupported. (often used to secure long spans)
- DEFECTIVE CONSTRUCTION -
Floor Plank
Inaccessible spaces between built up timbers, used for Girders
Wood Furring and Hollow Spaces in walls and partitions
Hollow Spaces in Floors
No Parapet Fire Walls between buildings
Roof Line
Timbers built in thin Party walls
Insufficient or no space between joist or beams in division walls.
FLOOR
JOIST
Hollow Spaces in Steep Roofs
Thin Walls laid up with poor morter & poor joints
Boxed Cornices or hollow concealed Spaces.
Poor Masonry Work in Chimneys
Stove Pipe holes without Collars where passing through partitions, or wall of chimney
Hollow Spaces
Floor timbers near Flues
Chimneys and Flues without suitable foundations (often supported by joist and by corbeling out the brick work)

FIGURE 14

and inspected at frequent intervals. There are many fire doors and fire shutters, so-called, which are absolutely of no use in furnishing protection for the door or window openings. Not only are doors and shutters frequently improperly constructed but are ineffectively installed or not properly looked after from time to time. Frequent defects in fire doors and shutters consist of the improper jointing of the tin work and improper method of nailing under the seams. These are defects which often cannot be observed at a casual inspection, but can only be detected by opening up the seams. Exposed nails in the tin work are always defects. Doors are often hung on light or insecure tracks or hinges, the condition being aggravated by the presence of wood work used in supporting or blocking up the tracks; combustible door sills, improper guides and stops all tend to reduce the effectiveness of these structural features. Fire shutters secured to wood window frames frequently exist and are about as useful as no form of protection.

Consideration of Occupancy.—There is no feature of more importance in the construction of a building than the thorough consideration of the proposed purpose for which it is to be used. Correct constructive features differ with different classes of buildings and locations. Common defects in construction are the improper arrangement of the rooms or grouping of buildings which contain the hazardous features, or the exposing of valuable contents to the resultant conditions of smoke, fire and water; the improper use of constructive materials to withstand depreciation, or the action of gases, steam, etc., in connection with the internal appurtenances; the lack of properly planned ventilating ducts or flues often requires the marring of structural features and the cutting of unnecessary holes through walls and floors, and proper provision for wire or pipe shafts is often overlooked in the constructive process. Improper supports for machinery or concentrated loads often require the addition of structural members which cannot be installed without detracting from the original type of construction. The arrangement of structural features to suit the special conditions of fire protective devices should not be overlooked, as excessive costs can often be avoided, if future fire protective devices are considered in connection with the constructive materials.

HEAT

From scientific tests the following conclusions have been reached relative to the temperatures developed by fire under various conditions, and these results should serve as a guide in determining the class of materials or type of construction to suit various requirements:

The heat developed by a common wood fire is about 1000° F.

The heat developed by a charcoal fire is about 2200° F.

The heat developed by a coal fire is about 2400° F.

The heat of a burning structure is at least 1000° F.

A mild external fire develops at least 1200° F. for one hour; 700° to 1000° F. for about one-half hour indicates a mild condition such as would generally occur in an office building or dwelling where such structures are under the protection of a public fire department.

A conflagration develops at least 2500° F. for a period of six hours. Oil fires or fires in lard refineries are extremely severe, developing temperatures as high as 4000° F.

TEMPERATURES

The following table gives a list of temperatures developed in iron and clay working industries:

			Degrees Fahrenheit
Shale	Drain tile	Bottom kiln	1600
Composition	Earthenware	Kiln best heat	1860
Fire clay	Stoneware	Hottest part of kiln	2922
Fire clay	Stoneware	Hottest part cooling	1900
Fire clay	Stoneware	Bottom best heat	1950
Fire clay	Sewer pipe	Kiln best heat	1920
Fire clay	Brick and terra-cotta	Kiln best heat	2200
Shale	Sewer pipe	Kiln best heat	1862
Fire clay	Paving brick	Kiln best heat	1920
Shale	Paving brick	Kiln best heat	1800
Boiler	Under	Under stoker arch	2295
Ingot	On table	Being rolled	1950
Ingot	Heating furnace	Ready for rolling	2120
Bessemer steel	Pouring	Ingot	2550
Open hearth steel	Pouring	Ingot	2620
Blast furnace	In furnace	Ready for tap	2660
Blast furnace	Mill iron	Running	2225
Blast furnace	Bessemer iron	Running	2295

Open hearth and blast furnaces develop temperatures in molten metal up to 3000° F.

Good Portland cement is manufactured at temperatures from 2600° to 3000° F.

Sand does not fuse until a temperature of above 2900° F. is reached.

Temperature of glass melting furnace	2500 to 2600° F.
Melted glass	2400°
Annealing bottles	1100°
Bright iron becomes yellow at	400°
Bright iron becomes red at	500°
Bright iron becomes indigo at	550°
Bright iron becomes gray at	750°
Tin melts at	445°
Lead melts at	612°
Zinc melts at	775°
Copper melts at	1885 to 2000°
Cast iron melts at	1900 to 2200°
Wrought iron melts at	2500 to 2912°
Platinum melts at	3227°
Steel melts at	2500 to 2790°
Aluminum (cast)	1157°

COMBUSTION

According to the experiments of Kerl, the initial heat or temperature to be reached to allow the particles of carbon to properly ignite with those of oxygen is as follows:

Peat	437° F.
Pine	563° F.
Soft coal	619° F.
Charcoal made by low heat, say 280°, will ignite at	360° F.
Charcoal made by higher heat, say 750°, will ignite at	380° F.

THE EFFECTS OF FIRE ON ALL FORMS OF BUILDING MATERIAL

Wood in the form of small units is highly combustible and has no fire resisting qualities; in bulk or heavy timbers it burns slowly after the outside has become charred, as the charring acts as a non-conductor to the heat. Large timbers have withstood the direct action of fire without impairing the strength of the floor construction whereas structural steel under similar conditions has utterly failed.

The inflammability of timber is in proportion to the structural compactness of the pores, timber of the character of oak being less readily inflamed than pine.

Fire resisting wood has been successfully used in the navy department of the United States Government, and is acceptable as a fire retardant under certain conditions under the New York Building Code. Severe tests have been made on properly treated wood which indicated its merits as a non-inflammable material, but as the expense of properly treating wood is considerable, and as a number of faulty processes have been used, the use of fire resisting wood has not been extensive, nor has its effectiveness been proved by the ageing of the wood so treated and the possible chemical changes due to varying atmospheric conditions.

Certain kinds of treated woods are likely to absorb moisture, or the wood fibres might become weak or brittle; under such conditions it is a question whether it is wise to consider wood so treated as a constructive material.

The tests of treated and untreated woods show that the tendency of untreated woods to burn is ten to twenty times that of treated woods.

The fireproofing of wood is most successfully accomplished by the processes which thoroughly impregnate all the pores to the heart of the timber using such chemicals as are not hygroscopic or efflorescent in character. The chemicals used should be of such a nature as will not corrode structural metal work used in connection with the timbers, and only such chemicals should be used as will admit of the cremation of the wood without flame.

Compounds of ammonia have been successfully used as the ready volatility by heat of such compounds produces gases which do not support combustion or burn of themselves.

"Fireproof" paints are used extensively for the protection of wood work but their effectiveness is limited and depreciates in time; as a protection to wood work such paints have been known to resist the action of a mild fire for periods of from fifteen to twenty minutes. Paints in the form of tungstate of soda and asbestos paint are extensively used. Silicate of soda and lime wash applied in alternate coats will decrease the probability of ignition to wood work in the case of incipient fires.

The formula for whitewash as adapted by the United States Government, when properly applied to wood work, affords a good fire retardant.

Whitewash—Formula Recommended by the Lighthouse Board of the United States Treasury Department.—Slake one-half bushel of unslacked lime with boiling water, keeping it covered during the process; strain it and add a peck of salt dissolved in warm water; add three pounds of ground rice, put in boiling water and boil to a thin paste; add one-half pound powdered Spanish whiting and a pound of clear glue dissolved in hot water. Mix these well together and let the mixture stand for several days. Keep the wash thus prepared in a kettle or portable furnace, and when used put it on as hot as possible with painter's or whitewash brushes.

Where possible the coatings should be applied by a hand brush rather than by a spraying machine, thus effecting a better surface, and special care should be taken to keep the whitewash off of the sprinkler heads.

STONEWORK

In considering the resistive qualities of various kinds of stone, it is necessary to determine the conditions due not only to the influence of heat, but the resultant disintegration due to a rapid change of temperature which is likely to ensue from the action of the water thrown in hose streams on the heated stone in case of fire.

A stone which under certain conditions may stand up very well will disintegrate under other conditions. Some stone or granites act badly on fast cooling, yet under the combined action of flame and water have suffered little damage. Sudden cooling is conducive to disintegrating the general forms of stonework, damage being more pronounced in rocks of coarser texture. The more compact and hard the stone the better it will resist extreme heat; the greater the absorption the greater will be the effect of heat. A very porous sandstone will be reduced to sand, and a stone in which the cement is largely limonite or clay will suffer more than one held together by silica or lime carbonate.

Limestones up to the point where calcination begins (600° to 800° F.) will be little injured, but above that point they fail badly owing to the crumbling caused by flaking of the quicklime.

Marble behaves similarly to limestone but on account of the coarseness of texture also cracks considerably.

Sandstone will stand up fairly well at temperatures from 800° to 1000° F. but cracking can be expected along the bed of the stone, and the stability of structural members would be endangered if the stone had not been properly set. At 1500° F. severe injury could be expected, as there is no possibility of local expansion or contraction without rupture.

Granite.—Crumbles rapidly, disintegrates and cracks under normal degrees of heat, which is due to the coarseness of texture and the differences in the co-efficients of expansion of the various mineral constituents. Some minerals expand more than others and the strains occasioned thereby will tend to rupture the stone more than where the mineral composition is simpler.

BRICKWORK

Brickwork of properly burned brick, and properly laid up in strong mortar, with good solid well filled joints constitutes a form of construction which in point of efficiency cannot be excelled as a fire resistive material. This is due to the homogeneous texture and the joints which makes it possible for each joint to assist in taking up the expansion stresses without rupturing the main body of the brickwork. When used as fireproof coverings the expansion stresses are not severe as the homogeneous nature of the material prevents a rapid change of temperature between the exposed face and the interior side of the brickwork, thus eliminating the destructive expansion stresses. Hard dense bricks will spall on the exposed surface which does not to any extent affect the efficiency as a protective covering.

The fire resisting property of bricks depends chiefly upon the amount and relative proportions of the silica and alumina contained in the clay from which the bricks are made; the greater the proportion of alumina to silica the greater is the infusibility of the clay. The most refractory bricks are however not the strongest for structural purposes. The best bricks for building purposes should be burned just short of vitrification.

Fire brick has not been excelled as a resistive material to high temperatures. The linings of steel melting furnaces which are constructed of this material are required to insulate up to 3000 degrees of heat; the brickwork in such cases is from twelve to fourteen inches in thickness, which insures the proper insulation; at the same time the expansion stress in the brickwork is very slight.

CONCRETE BLOCKS

The proper manufacture of concrete blocks is an art accomplished by few at the present time. Walls constructed of concrete block have passed through mild fires without damage, but the percentage of failures is considerable. A good type of construction for small buildings or where high temperatures or long continued fires are not likely to occur, is of well made concrete blocks. Cement blocks should not be used for fire walls or where conditions are such that they would be subject to severe fire.

Hollow blocks of concrete as set in the walls or floors of a building usually present but one surface or face to the direct attack of fire and the consequence is that one side or face of the block expands rapidly under the influence of heat, while the other three sides receiving much less heat do not expand nearly as rapidly, with the result that the hottest side breaks away from the others.

TERRA COTTA

The fire resistive qualities of terra cotta are governed by the nature of the clays entering into its composition, the method of burning, arrangement and thickness of the webs and cellular construction, the size of the units or blocks and the manner of setting the material in connection with the structural frame of the building. The structural defects of terra cotta can readily develop in a fire of no great magnitude and the ultimate efficiency of the material can only be secured by the proper care in manufacturing and installation.

Terra cotta should be of adequate thickness and weight, with heavy webs and partitions; the corners should be arranged with well rounded fillets and the blocks should be substantially constructed. For effective coverings the minimum thickness of the material should not be skimped. The disastrous results to terra cotta as a fire protective material have been due to the insufficient thickness of the material, and the method of installation. In many cases terra cotta has been but a thin veneer without protecting the structural metal work against fire. Webs of tiles should be at least one and one-half inches thick with interior angles rounded to a radius of two inches. A weakness from a fire protective standpoint is frequently developed in buildings of irregular form where the beam lines and side walls or girders intersect at acute angles. Much difficulty is experienced and much imperfect work in the setting of tile often results in the patching out of cut pieces of tiling for the purpose of filling out the irregular angles and intersections.

The chief weakness in terra cotta has been due to the large size units employed and the thin exposed webs which are incapable of sustaining the expansion stresses. With a rapid change of temperature thin webs have not the required resistive qualities, permitting fractures and ultimate failure. The damage by fire to the soffits of terra cotta arches is due to the unequal expansion between the shells and webs of the arch blocks, the shells receiving much more heat than the webs.

Semi-porous terra cotta properly made of fire clay can be heated to redness and plunged into water without disintegration and with the proper application of same, structural metal work can be effectively protected against severe fire.

IRON AND STEEL

Cast iron, steel, and wrought iron appear to increase in strength in temperatures up to about 400° F.; as the temperature rises above this point the strength is rapidly depreciated; this is especially the case with wrought iron and steel.

Structural steel at about 575° F. loses about 10% of its strength.

Structural steel at about 750° to 800° loses about 50% of its strength.

Structural steel at about 1000° to 1200° loses about 75% of its strength.

Hard steel has a higher resistance to heat than soft steel; experiments by Howard prove that 0.10 per cent. carbon steel had a strength of 20,000 pounds per square inch at 1000° F. and 0.60 to 1.00 per cent. carbon steel had the same strength at 1600° F. Steel columns will yield under loads at from 1000° to 1200° F. Cast iron has stood up to 1300° to 1500° F. for a short time but the throwing of water on cast iron when highly heated may cause it to crack or fly to pieces. Cast iron columns should not be used in high buildings as their failures are usually complete, which results in a sudden total collapse of the sections supported. Beams or girders cannot be rigidly attached to such columns and defects in the material cannot readily be detected. Wedges and blocking pieces are frequently introduced in connection with cast iron columns for the purpose of trueing up the structure. Such a feature is often unobserved until the action of fire or shock, which usually results disastrously.

Irregular heating of structural steel, such as may take place when a beam or girder is partly encased in a wall, or when the lower portion of the structural metal work is unprotected, produces a dangerous condition as the excessive internal strains tend to induce twisting and distortion or the stresses due to expansion may be sufficient to throw the walls of a building.

COMPOSITION FIRE RESISTIVE MATERIALS

Resistive materials such as plasters having **gypsum** as a base offer a great degree of resistance to heat. With proper compounding of such materials and when the blocks or slabs are properly arranged they afford good barriers against fire. Gypsum retains its cohesive power when subjected to high temperatures and to hose streams; if however such a condition is present for any length of time the calcined surface of the material may be washed away without a total disintegration or breaking up of the material.

Asbestic plasters when laid on a solid foundation are a good fire resistant, the customary thickness being from three-quarters to one inch.

Asbestos building lumber is used extensively for shingles and siding, and is considered superior to wood when arranged in connection with proper supporting members.

Composition wood is made from ground straw or straw board with a cement or composition binder, the materials being subjected to heavy pressure, and forming a compact board, which is non-combustible and is considered a good non-conductor. If the material is of sufficient thickness it is but slightly affected by high temperature and a subsequent application of water.

Plaster of Paris.—While plaster of paris is a well-known non-conductor of heat, such compositions absorb moisture rapidly and dry slowly; they soften under fire streams and are rapidly disintegrated.

Air spaces in connection with fireproofing if arranged in such a manner that flues will not exist for the conveying of the heat or gases, that is if such spaces are "dead," afford good protection to structural metal work, as such spaces will permit the transmission of heat only by radiation, a much slower process than by direct contact. When designed so as to form two or more thicknesses of insulating material with air spaces intervening the efficiency is largely increased. Wire lath and cement or plaster arranged on suitable furring provides a very good protective material.

WIRED GLASS WINDOWS

Wired glass in approved metal frames is an excellent fire retardant; although it will crack under the influence of fire, it will retain its position when subjected to a rapid change of temperature due to the application of water. Under the continued application of heat as would be present in a conflagration, the glass could radiate sufficient heat to destroy combustible materials in the immediate vicinity within the room they are intended to protect. Wired glass windows form the best known safeguard for the prevention of fire spreading from one floor to another through the outside window openings, especially in buildings of non-combustible or fireproof construction, and of several stories in height.

EFFECTS OF FIRE ON CONCRETE

Good Portland cement is manufactured at temperatures of from 2600° to 3000° F. The fire resistive qualities of concrete are governed by the nature of the cement, sand and stone, the proper proportioning and mixing of these materials and the care exercised in applying the concrete mixture in the construction work.

Cement varies in its chemical properties, and may to all outward appearance seem good, but the only safeguard where cement is to be used for structural purposes, is to subject it to a physical test. Failures have been caused by a low percentage of lime in the cement, a specific gravity below normal with an undue amount of volatile matter in the cement. The strength of concrete is due to the hydration of cement which in setting takes up a certain amount of water in crystallization which is essential to its strength. At a temperature of about 600° F. this water begins to be driven off and the cement loses its strength. When dehydration is complete the strength is gone. However, the dehydration being a slow process, and as the dehydrated material is a poor conductor of heat the interior of the mass is thus slow to dehydrate. Twenty to twenty-five per cent. of the weight of concrete represents the amount of moisture which is chemically combined in the proper setting of cement; dehydration represents the evaporation or driving off of this vapor from the pores of the concrete. It frequently happens that concrete is laid in places where it is to be exposed to a temperature of from 400° to 500° F. It has been demonstrated that concrete will stand this temperature provided it has previously been allowed to thoroughly harden. If, however, it is subjected to any such temperature as this within a short time after being laid, the effect is to dry it out, not leaving sufficient moisture present for its proper hardening.

Concrete will resist extremely high temperatures for brief periods, say four to five hours. Stone concrete subjected to temperatures up to 2000° F. and suddenly cooled by hose streams has been known to disintegrate to a depth of 1¼ inches from the surface, the interior of the mass being intact. Concrete under long continued temperature of over 700° F. will ultimately disintegrate. Concrete will resist 500° F. for an indefinite period if mixed with proper proportions of good sand and trap rock. The question as to the superior qualities of cinder concrete as a fire retardant is one that has received considerable attention.

Cinder concrete is known to have undergone temperatures of 2000° F. and when suddenly cooled by hose streams none of the material was dislodged, the theory being that the cement and cinders being chemically similar the masses bind together upon the application of heat. It should, however, be considered that cinder concrete has but half the compressive strength of good stone concrete, and ultimately the strength of cinder concrete when subjected to high temperatures would be proportionally weakened.

Gravel concrete will crack and crumble in pieces long before trap rock or cinder concrete will develop any weakness under the same temperatures. The relatively large coefficient of expansion of quartz or flints, which form the integral part of gravel, is responsible for the breaking down of the concrete mixture when subjected to high temperatures.

Trap rock concrete is considered as a whole superior, as Feldspar which is one of the predominant minerals has a coefficient of expansion of but one-half of that of quartz.

Limestone Concrete.—Pure limestone is considered a very good aggregate and will not decompose until after the cement loses its resistive qualities.

Reinforcing Metal in Concrete.—The experiments of reinforcing metal in concrete indicate that where the reinforcing metal is exposed in the progress of a fire, only so much of the metal as is actually bare to the fire is seriously affected by it. Portland cement, concrete and steel are acted upon by temperature precisely to a similar degree, expanding and contracting in a uniform manner, or the coefficient of expansion and contraction of concrete and steel are to all practical purposes the same. The adhesion between the concrete and steel affords a powerful resistance to sudden cooling. The inherent strength of well mixed concrete and its ability to sustain a heavy shock or impact makes it important as a fire resistive material. The thickness of concrete on the exposed sides of the reinforcing metal to properly protect the same from fire, is working to a fixed standard among the best informed engineers. The consensus of opinion is that there should be at least one inch of concrete between the nearest point of a bar to the ceiling in panels, at least two inches below the steel in beams and girders, and also two inches of concrete outside of vertical bars in columns.

In designing columns many engineers figure only that area of the column inside the vertical bars, when hooped, as carrying the load, or if hoops are omitted and but light reinforcement is used to prevent bending stresses to add an extra inch beyond that needed to carry the load, all around the outside, which might be burned away without endangering the load carrying capacity of the balance of the column within. If this is burned off it can be plastered back giving the column the same fire resisting qualities as before. The fire resistive qualities of concrete structures are also governed by the protection that can be most effectively applied in the extinguishing of fire that might originate in the contents within such a structure. These forms of structure where the beam and slab arrangement is similarly arranged to a standard mill building, admit of the possibilities of securing the most effective results from hose streams, as the streams can be directed with a greater force and remaining unbroken thus secure the maximum horizontal limit of the stream where it hits the ceiling. Sprinkler protection can also be arranged effectively; whereas in the case of a number of pockets being formed in the ceilings by small intermediate beams there is a danger from the heated air being held in these pockets, which, under certain conditions, transmits the heat through to the floor above.

Some Tests on the Effect of Fire on Building Materials

At the recent annual meeting of the National Association of Mutual Insurance Companies, Mr. James E. Howard, engineer-physicist of the Bureau of Standards, read a paper on the properties of building materials which are influenced by fire. Among the diagrams he presented was one, Fig, 15, showing the probable expansive force which would be developed by confined materials when the temperature is raised. The figures on the diagram are based on the moduli of elasticity and the co-efficients of expansion of the materials. A range in temperature of 160° Fahr. was used, since this change in temperature will cause an expansion in a steel bar equal in amount to the extension which it will display under a stress of 30,000 lbs. per square inch, that is, equal to the extension of a piece of mild steel at its elastic limit.

Three predicted values are given for brick, to represent the behavior of hard, light hard and salmon brick. The very low value for salmon brick is significant.

Lime mortar is very compressible, and makes a good cushion in a wall for the stronger brick to act upon when heated. These expansive forces must be guarded against or may be neglected according to the kind of material or its position in the structure. It will be noted that the range in temperature here considered, only 160° Fahr., is an exceedingly limited one; if, however, these predicted values are approximately reached the gravity of thermal changes in causing disrupting forces may be realized.

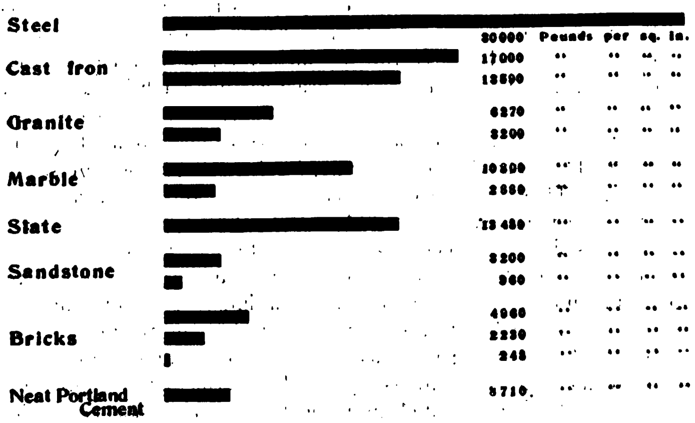


FIGURE 15

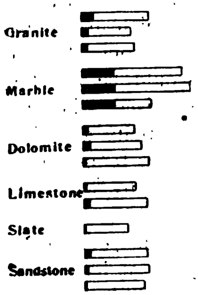
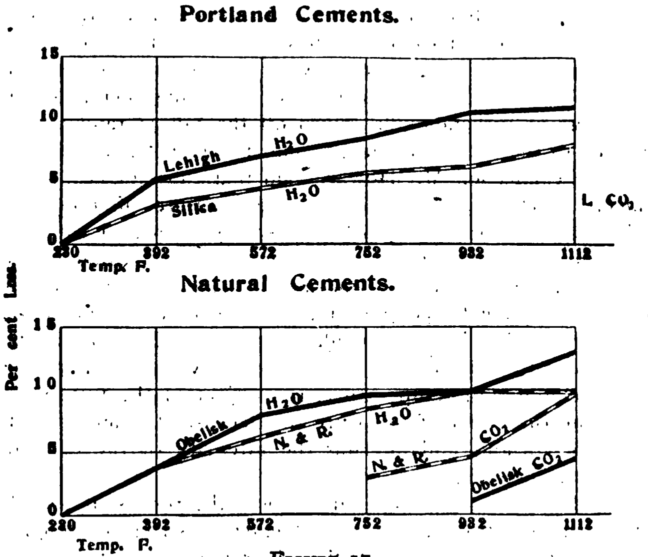


FIGURE 16


Portland Cements.

Natural Cements.

FIGURE 17

Another of Mr. Howard's diagrams, Fig. 16, shows the relative expansion of a number of building stones after exposure to a temperature of about 400° to 440° Fahr. The open lines of the diagram indicate the approximate expansion of the stones when heated, while the portions showing full lines represent the permanent expansion which remained after they had returned to the initial temperatures. It will be seen from the results that stones, when even moderately heated, do not return exactly to their primitive dimensions, but retain as a permanent set some of the expansion which they acquired when hot. These permanent sets are comparatively small, amounting to but a few thousandths or ten-thousandths of the length of the sample, but nevertheless from the persistence with which they appeared in each case are believed to be there.

Still another diagram, Fig. 17, shows the loss in water and in carbon dioxide of samples of ground hydrated cements. One Portland and two natural cements are represented, also a composite cement, Silica brand, made of one part Portland cement and one and a half parts of crushed limestone. Water of combination was successively driven off in this hydrated material as the temperature was raised from 230° Fahr. to redness. This would seem to indicate a want of stability in the chemical state of the hydrated cement or a state the equilibrium of which is disturbed at comparatively low temperatures. Hygroscopic water was driven off by initially heating the material at 10° Cent. above the boiling point. The large percentage of carbondioxide driven off the Silica brand of cement was due to the limestone entering into its composition.

In this connection Mr. Howard said that cubes of neat Portland cement, which were exposed to a temperature of 1,000° Fahr., within a short time thereafter gradually displayed cracks and eventually broke up into small fragments. The heating was done slowly, consuming one hour in raising the temperature, maintaining the maximum temperature for a period of one hour, and then cooling the cubes in dry powdered asbestos. This careful treatment was adopted so as to avoid destructive internal strains by sudden changes of temperature, the object of the test being to determine the effect of exposure to successively increasing temperatures without endangering the integrity of the cement by violent thermal changes.

Two diagrams were prepared to show the results of some temperature observations taken at the center of sticks of Douglas fir. One diagram, Fig. 18, gives the observations on sticks exposed over a wood fire for periods of 2½ hours for each stick. One stick was quenched with water at the end of this period of time, another was smothered with sand and ashes, while the third was taken from the fire without quenching. The sticks originally were 10 in. square by 4 ft. long. There was a hole bored at the center for a depth of 2 ft. and a thermometer inserted in this hole indicated the temperatures which are plotted on the diagram.

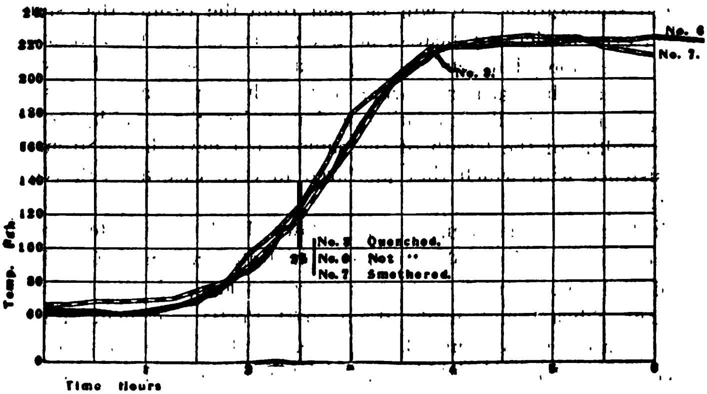


FIGURE 18

It will be noted that no substantial rise in temperature was felt at the center of the sticks during the first hour over the fire. After this there was a rapid rise, which continued for some time after the sticks had been quenched or withdrawn from the fire. The temperature of the fire was estimated to be 1,380° Fahr. The sticks were burned until they were from 6 to 7 in. square.

Compression tests made on the wood after scraping off the charred portions showed the unburnt portions to have retained their strength unimpaired. In fact, the thorough drying of the core was to its advantage apparently, since the compressive strength of the central portions gave results above the average for this kind of wood. Some long leaf pine posts, charred by a fire which occurred in the upper story of a building, also displayed compressive strength equal to and in some sticks above others from the same building which had not been charred.

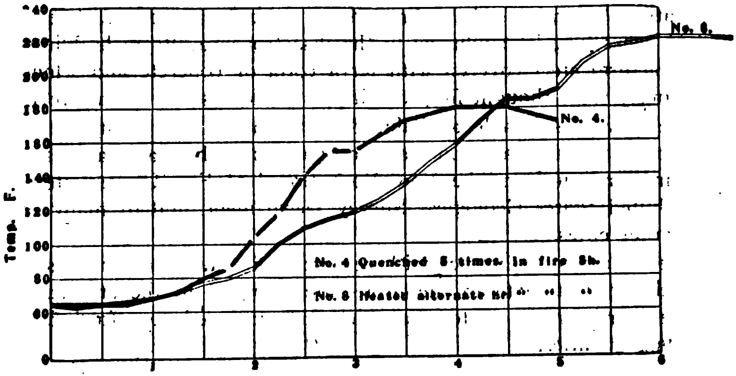


FIGURE 19

The second diagram, Fig. 19, shows other sticks of Douglas fir, which were also exposed over a wood fire. One stick was quenched with water after having been over the fire for 1¾ hours and immediately returned to the fire, which operation was repeated five times; after the sixth quenching it was cooled in the air. The other stick was exposed to the fire during alternate hours for three hours, then taken from the fire and smothered.—From The Engineering Record, Dec. 3, 1910.

Structural Steel Protected with Terra Cotta or Concrete as Applied to Fireproof Buildings.—The use of structural steel in modern building construction is necessitated by the commercial economics which impose the following requirements: 1st, The maximum of unencumbered floor space. 2nd, The maximum of height. 3rd, Abundance of natural light. 4th, The resistance to destruction by fire and the elements. The congestion of business centers within confined areas which involves building sites having large values is a condition which is arising and growing in all quarters of the universe, and while attempts have been made to discourage the erection of skyscrapers, the demand for high buildings is on the increase. As the surroundings of modern structures in built-up communities will prove more or less of a menace for many years to come, the elimination of conflagration hazards cannot be expected in this generation; therefore, the modern building constructed with a structural steel frame should not only be immune from the conflagration hazard but it should involve such features as will prevent it from being a conflagration breeder or carrier. These requirements are not unknown quantities at the present time, as the reports of experts relative to the several well known conflagrations in the past have brought to light the structural defects which were largely conducive to the disastrous results in buildings of structural steel covered with terra cotta or concrete and which previously were thought fireproof in the modern sense of the word.

There is considerable available data as to the fire resistance of building materials, based on the investigations of the National Board of Fire Underwriters, the New York Board of Fire Underwriters, the United States Geological Survey Department, and of many of the larger cities.

The degree of endurance with respect to fire and the elements is directly proportionate to the protection afforded to the structural frame work by the materials which are supposed to afford fireproofing qualities.

Any and all materials, whether terra cotta, concrete, brick or stone, are likely to fail as retardants against fire if proper consideration has not been given to these questions, and the materials chosen and assembled, accordingly.

The reports prepared by the various committees of the National Fire Protection Association bearing on the several conflagrations in the past show that many structural steel frames were not only improperly protected by unreliable materials, but the materials themselves were poorly assembled. The building laws of the larger cities are sufficiently flexible to admit of several types of materials for fireproofing purposes. As the deteriorating effects of moisture, electrolysis, vibration, and chemical action have an important bearing on the resistive qualities of structural steel the fireproofing materials should be governed accordingly, and only such materials should be adopted as will preclude the above conditions from arising within the structure itself, as resultant effects of either electrolytic or moisture leakage from pipe lines which must necessarily exist in all portions of the structure.

The conclusions set forth in the report of the New York Board of Fire Underwriters in relation to the Parker building fire which occurred on January 10, 1908, illustrate fully the need of a proper standard and enforcement of the same, in the design and construction of fire resisting buildings. The Parker building was considered on a par with average representative fire-proof buildings; in fact many structures in various parts of the country which are so called fireproof are to-day inferior to this example. That such a building should meet with practical destruction from a fire in a city where the fire department is of such magnitude is almost inconceivable to the general public, but the results should not be surprising to the layman when the conclusions of the New York Board of Fire Underwriters which follow are reviewed.

1. "In buildings of mercantile, manufacturing or storage occupancy, it is absolutely essential that all vertical openings be thoroughly enclosed in *substantial* fireproof shafts having standard fire doors at all openings, or so arranged that the shaft is without openings directly into the various stories. Unprotected vertical openings through buildings are the greatest factor in the loss of life and property by fire and the proper safeguarding of this hazard demands the most careful attention of all concerned.

"The unprotected vertical openings through the floors furnished the condition which was the main cause of the rapid spread of fire and the almost total destruction of the Parker building and its contents.

"High buildings filled with combustible materials and having unprotected vertical openings present fire conditions which are very apt to be beyond the control of fire departments, no matter how efficient or well equipped. Promptness of discovery, nature of the contents, proximity of the fire to vertical openings, area of the enclosure in which the fire occurs and distance above the street, all influence the chances of control of fire in such buildings.

"That the danger of the rapid spread of fire through unprotected vertical shafts also exists to a very considerable degree in fireproof office buildings, is evidenced by the great rapidity with which several such buildings were destroyed in the San Francisco conflagration. The buildings to which reference is made were not subject to general conflagration conditions."

The unprotected floor openings in the Equitable building played the most prominent part in the destructive fire by making possible the quick spread of the flames from the small receiving room in the basement to all the upper floors. The use of a few fire doors at the communications with the dumb waiter shaft would have confined the fire to the shaft and left the balance of the building with little or no damage.

2. "The height of fireproof buildings of mercantile, manufacturing or storage occupancy should be limited to correspond to the degree of protection the building equipment and the fire department is able to furnish. In other words, if adequate fire protection in any building is not available above a certain height, the building should be limited to such height."

The fire in the Parker building furnished an excellent example bearing on this question. The Equitable building fire demonstrated fully the need of fire protective devices such as automatic sprinklers, smoke-proof stair towers in combination with stand pipe equipments, one or more interior fire walls and protection against exposing buildings.

3. "Buildings of large unbroken floor areas filled with combustible contents develop the severest fires and constitute one of the most dangerous sources of general conflagration. Floor areas in buildings of this character should be sub-divided by substantial *brick* fire walls sufficient to form a positive barrier to the spread of fire."

The fire in the Equitable building demonstrated the fact that the above comments can apply with equal force to office buildings; corridor partitions in every fireproof office building should be effective fire stops, utilizing fire doors; any glass if used in transoms should be wired glass.

4. "Fireproof buildings, no matter how well designed and constructed, do not prevent the destruction by fire of contents in any story; and it is essential that high buildings of mercantile, manufacturing or storage occupancy be thoroughly protected by a standard equipment of automatic sprinklers."

In the design of such structures it is important to consider the proper location and arrangement of the water supplies, with special reference to the size and suitable location of gravity or pressure tanks to meet the requirements of the Underwriters.

5. "Exterior openings in buildings should be thoroughly protected against exposing fires. Universal efficient fire protection of exterior openings will practically eliminate the danger of conflagrations in cities.

"Fires in buildings containing large quantities of combustible contents generate large volumes of gas and flame which must find exit through the windows. The necessity for effective window protection to prevent such fires from re-entering at other stories was again demonstrated at the Parker building; wired glass windows in standard metal frames are particularly well adapted for protection against exposure of this character, but should not, alone, be depended upon at points where the exposure from the exterior is severe.

"Exterior openings in buildings can be effectively protected against exposing fires by standard fire doors and shutters, steel rolling shutters, wired glass in standard metal frames, open sprinklers, or combinations of these devices. However, the fire retardant qualities of these various devices are not equal and their selection for use should depend on the severity of the exposure.

6. "High buildings of mercantile, manufacturing, or storage occupancy should be provided with large, properly enclosed stairways in sufficient number to afford a safe exit at time of fire. Such buildings should also be provided with outside fire escape and stand pipe equipments.

7. "Buildings of mercantile, manufacturing or storage occupancy should be provided with adequate systems of inside stand pipes equipped with linen hose and nozzles suitable for fire department use, and, in addition, a smaller linen hose and nozzle suitable and safe for the use of occupants. These equipments should be accessible and in sufficient number to effectively cover all portions of the building. They should extend through all stories and should be supplied from a reliable source of water under adequate pressure, in addition to siamese steamer connections on the outside or street level.

"*Cast iron columns* should not be used in high buildings, as their failure is usually complete, and results in sudden total collapse of the sections supported. Girders and beams cannot be rigidly attached to such columns and defects in the material cannot be easily detected.

"Although most of the columns in the Parker building were intact, the failures noted were responsible for the loss of three lives and serious injury to many firemen, the destruction of large portions of the building and the loss of considerable property in lower stories which would not otherwise have been destroyed. In contradistinction, the failure of steel columns is gradual and does not often result in the total collapse of the sections supported. This was fully demonstrated in the San Francisco conflagration, where the serious deflection of hundreds of steel columns did not result in the total collapse of floors, except in one or two instances."

The Equitable building fire fully demonstrated the failures of cast iron columns. There were three separate and distinct collapses of portions of the floors and the initial collapse in each case was apparently due to the failure of unprotected cast iron columns.

"It is essential that all *structural members of fireproof buildings* be protected by a sufficient mass of fireproofing to thoroughly insulate them against the heat which would be developed by the rapid burning of all materials permitted in any story of such building. It is also essential that all fireproofing be firmly anchored, or otherwise securely held in position, where it is of such a nature or so designed that it will become loose as a result of heat. On account of their great importance structurally, columns should be insulated by at least four inches of fireproofing; and no pipes or conduits should be placed in or back of the fireproofing material. On account of the heavy mass of fireproofing with which girders and floor beams are in contact a lesser amount of protection can be safely employed at the soffits; generally this should not be less than two inches for girders and one and one-half inches for floor beams.

"*Buildings of large area* and buildings in which large quantities of combustible materials are stored, require heavier and more efficient fireproofing than buildings of moderate area and those containing limited quantities of fuel. The tendency has been towards lightness and cheapness, and fireproofing is often reduced to a point where unsatisfactory results can be expected."

There is always the possibility of a quick spreading fire even in office buildings; the Equitable bilduing fire was of sufficient intensity to cause the deflection of wrought-iron beams with only their lower flanges unprotected.

"*All floor arches* should be provided with a large factor of safety so as to safely carry the imposed loads; not only under ordinary conditions, but when severely exposed by fire. The arches in the Parker building were weak, particularly the wider spans. Many collapsed as a result of the impact of material falling from the upper floors, thus carrying down the arches in several floors below. In many places the arches were knocked through by heavy safes and machinery, which settled or fell when wood floors and supports were burned. Quite a number which had no heavy loads above them collapsed as a result of fire. The majority of the arches which failed were on the six-foot spans, although the failures were by no means confined to these."

In the Equitable building the arch spans varied from 3 to 5½ feet; the terra cotta was 10 inches deep and the material and workmanship of the arches was apparently very good. As a result of the fire scarcely any of the tile was cracked off the lower web of the arch, except where exposed to the heat of the burning insulation on telephone and telegraph wires where the heat was unusually severe.

"*Arches of all forms in common use* are seriously damaged when directly exposed to high temperatures of long duration. In buildings containing large quantities of combustible material, they should be so designed or protected against fire that serious structural damage will be prevented."

Damage by fire to the soffit of hollow terra cotta arches is due to the unequal expansion between the shells and webs of the arch blocks; the shells receiving very much more heat than the webs.

"This is an inherent weakness and cannot be remedied by any practical increase in the thickness of the members. Additional lower cells in the blocks would in all probability prevent serious structural damage and permit of economical repair."

Substantial suspended metal lath and plaster ceilings, although resisting fire streams poorly after exposure to fire, afford sufficient additional protection to properly designed floor arches.

"*No wood or other combustible* material should be employed in the construction of fireproof partitions and all metal supports or reinforcements should be thoroughly insulated from heat. Fireproof doors and wired glass in standard metal frames should be used at necessary openings in corridor and room partitions. Provision for expansion in the material used and in metal supports entering into the construction of fireproof partitions is essential, particularly where hollow terra cotta blocks are employed. All fireproof partitions should rest on solid incombustible material.

"The unreliability of stair and elevator enclosures made of hollow terra cotta blocks and of partitions containing wood supports and large openings with wood doors and ordinary glass was again demonstrated by the Parker building fire.

"In buildings of fireproof construction all floor surfaces, doors, window frames, sash and other trim and finish should be of incombustible material.

"The support of heavy safes and machinery on wood floors and wood skids in fireproof buildings is a menace to both life and property, and should be absolutely prohibited. Heavy shafting should be attached to ceilings in such a manner that it will not fall as a result of fire.

"Floors are seldom designed to withstand the impact resulting from the dropping or overturning of heavy safes, which are often supported six to twelve inches above the floor and commonly weigh from three to six tons. These loads should be safely distributed by means of steel framing resting on non-combustible material."

COST AND DEPRECIATION OF ALL FORMS OF BUILDING MATERIAL

DEPRECIATION OF BUILDINGS

The present values of buildings, as reduced from original values by depreciation, are more difficult to determine in an accurate and satisfactory manner than the majority of problems involved in building construction. Frequently this subject does not call for consideration on the part of property owners until the question arises during the adjustment of fire losses. This is particularly the case respecting properties which have changed ownership, and where different conditions in the nature of the occupancy have transpired.

There are so many influences which tend to bring about deterioration in structural materials, as well as structures in their entirety, that the question of depreciation is more frequently adjusted by compromise than by actual computation based upon a percentage of original value. Frequently the insurable values have been incorrectly calculated, because of the want of proper consideration of the question of depreciation; in fact, the actual profit and loss accounts of manufacturing interests can only be justly determined by instituting a building depreciation fund, in connection with the machinery depreciation fund. Such a fund should be sufficient at any time during the life of the business to offset the depreciation, so that the capital invested in the provision of buildings is always realizable at the full amount originally invested by the concern under this heading. The sum invested in a structure should be maintained at its original level, partly by the continued existence of the structure, which should stand on the books at a value, depreciating year by year, and partly by cash invested which would represent the depreciation in value. Such funds should be accumulated by means of a fixed charge upon the business according to the work done within the building. As the depreciation fund is built up, it can readily be determined whether the building has declined in its earning capacity to such an extent as to warrant its replacement. Consideration of this subject might also tend to show how the products of a manufacturing concern could be produced on more economical lines than was possible in the older structure. In behalf of the management the existence of a depreciation fund overcomes the financial difficulties likely to accrue in the question of modernizing existing manufacturing conditions.

Insurable values can be determined in a more accurate manner if a depreciation fund be maintained. If the property is overinsured there is a loss through excessive payments for insurance premiums, and where such conditions are manifested in the course of adjustments, the question of depreciation, if left unconsidered by the owner, becomes aggravating and often retards the progress of what might otherwise prove a mutually satisfactory adjustment of values. There is an annual depreciation on buildings of all descriptions, in addition to certain charges for maintenance and repairs. Opinions, however, vary as to the amount of annual depreciation for different types of structures as a whole.

Every property is more or less influenced by conditions peculiar to itself. To arrive at a proper understanding of depreciable values it requires not only a knowledge of materials and their assembly, but of the useful life of a building; considering the purpose for which it exists, the method of its use and the probable length of time that it may be expected to be required for that particular purpose. Many buildings are especially designed to turn out a certain product, being provided with special appliances to meet the requirements of that product. Such buildings would, probably, not be readily capable of adaptation to other purposes; and, even though substantially constructed of brick, stone or concrete, it would be good judgment to look upon them as falling in a class by themselves, instead of their being classified strictly according to their type of construction. In cases of this character it would be wise to consider the life of the building as comparatively short, which would naturally mean rather heavy depreciation.

The Home Insurance Company of New York has conducted extensive investigations into the cost of building in various parts of the country, and has arranged its data in a convenient form for architects and builders.

In addressing this to architects and builders, the Home Insurance Company seeks relation with the two professions that have the most to do with physical constructions that make for its interest. In part, it says: "Many considerations are weighed by a man who sets out to build a house; if a dwelling for himself, comfort and beauty; if a store, convenience and suitableness; if a factory, strength and adaptability. But, whatever other conditions are considered, there is one that, first and last, influences and generally dominates and controls, and that is the cost. That must always be counted. Is it always counted wisely? What is the true economy in house building? Admitting that a good building, even at a lower insurance rate, is better for us, can we establish that it is better for the owner? If this can be done, will it not be your pleasure and to your advantage to advocate a wise initial outlay of somewhat larger sums for buildings, to make good brick, stone or concrete walls; metal, tile or slate roofs; substantial chimneys from the ground—condemning and opposing the use of poor materials as not only inferior, but actually, in the end, more expensive from every point of view?

"Let us assume, for the sake of the argument, that one is to plan or erect a two-story building, to be occupied as a dwelling, a store or a factory, to be 25 feet front by 35 feet deep, making an area of 875 square feet; the first floor to be flush with the ground and the height of the building to the eaves to be 22 feet; having a pitched roof with peak 10 feet above the eaves—producing a roof area of about 1,120 square feet. This would make the surface of the four walls amount to about 2,890 square feet.

"We have secured estimates from a number of responsible builders in different parts of the country, principally South, made as though for a prospective customer, for (1) the walls, (2) the roof, (3) one chimney, and (4) probable depreciation of walls and roof for different materials. We have made an average of the figures given us, and in this way believe that they should be approximately correct.

Estimated Cost

WALLS (12 inches thick):

Stone	$1,301.00
(Estimates are for rough quarry dressed stone rather than fancy cut or ornamental work,)	
Brick	1,096.00
Reinforced concrete	838.00
Wood	619.00

ROOF:

Tin (painted)	$120.00
Slate	120.00
Tile	212.00
Shingle	87.00

CHIMNEYS:

Assume one chimney adapted for the entire building. Difference in cost for various types:

Brick.—Eight inches thick from the ground; three feet foundation, eight feet cellarway (if a cellar exists); 40 feet high above that; total, 51 feet.

Cost with one straight Flue from ground	$66.00
Cost with two straight Flues from ground	88.00

Cost of Flue, same dimensions, resting on second story beams, 25 feet, one Flue	$33.00
Cost of Flue, same dimensions, resting on second story beams, 25 feet, two Flues	46.00

DEPRECIATION:

Those given us average as follows:

	Per Cent. Per Annum
Stone Walls	1 ⅛
Brick Walls	1 ⅛
Concrete Walls	1 1-6
Wood Walls	2 8-10
Tile Roof	1 2-3
Tin Roof	4 ⅛
Slate Roof	1
Shingle Roof	8 ¼

Wood and shingles for walls and roof and a hung chimney have outset advantages in cost. That is why these types prevail. Are they, however, really any cheaper at the end of twenty years?

A good chimney resting on the ground is essentially a measure of safety in preventing fires. It will, moreover, represent a slight saving in maintenance, the amount of which can not be stated exactly, and it makes a material saving in insurance rate. For the standard type of construction (built from ground) there is a favorable difference in rate, running from 10 per cent. upwards.

If stone, brick or concrete is used for walls, no painting is needed. If wood is employed, it should be painted at least once in four years. Cost of same, say, $60. In forty-six years this alone would consume the extra cost of stone, in thirty-two years that of brick, and in fifteen years that of reinforced concrete.

A further economy in brick or stone, contrasted with wood, is the lessened cost of heating. The ordinary wood house develops cracks and openings in the walls, especially around the window frames, that permit the escape of heat, and the entrance of cold and wind, which make drafty places that are uncomfortable in cold weather and add to fuel bills. The writer has in mind a frame house built some years ago, which he planned to construct with brick filling. The contractor, with probably the best intention, recommended to omit this. It saved a couple of hundred of dollars, and as an offset to that economy (?) it would be safe to estimate that $20 worth of coal extra is needed annually to keep the house warm, besides which, in extreme weather, the rooms facing the cold west winds can not be made comfortable by the furnace, no matter how hard it is driven.

In addition to safety and preventing loss of life or injury by fire, promoting comfort and warmth (with saving in fuel) in winter, and conversely cooler and more comfortable in summer, which are not altogether measurable in dollars and cents, it is possible to make a fairly precise and accurate equation showing the benefit of a moderate increase in first cost by the use of superior materials and methods in construction.

FIRST, AS TO LONGER LIFE:

STONE WALLS AND TILE ROOF.—Cost per estimate, $1,513.00. Annual Depreciations, 1⅛ per cent. walls, 1 2-3 per cent. roof. Annual Depreciation equals $18.17.

STONE WALLS AND TIN ROOF.—Cost per estimate, $1,421.00. Annual Depreciations, 1⅛ per cent. walls, 4⅛ per cent. roof. Annual Depreciation equals $19.59.

STONE WALLS AND SLATE ROOF.—Cost per estimate, $1,430.00. Annual Depreciations, 1⅛ per cent. walls, 1 per cent. roof. Annual Depreciation equals $15.93.

STONE WALLS AND SHINGLE ROOF.—Cost per estimate, $1,388.00. Annual Depreciations, 1⅛ per cent. walls, 8¼ per cent. roof. Annual Depreciation equals $21.82.

BRICK WALLS AND TILE ROOF.—Cost per estimate, $1,308.00. Annual Depreciations, 1⅛ per cent. walls, 1 2-3 per cent. roof. Annual Depreciation equals $15.86.

BRICK WALLS AND TIN ROOF.—Cost per estimates, $1,216.00. Annual Depreciations, 1⅛ per cent. walls, 4⅛ per cent. roof. Annual Depreciation equals $17.28.

BRICK WALLS AND SLATE ROOF.—Cost per estimates, $1,225.00. Annual Depreciations, 1⅛ per cent. walls, 1 per cent. roof. Annual Depreciation equals $13.62.

BRICK WALLS AND SHINGLE ROOF.—Cost per estimates, $1,183.00. Annual Depreciations, 1⅛ per cent. walls, 8¼ per cent. roof. Annual Depreciation equals $19.51.

CONCRETE WALLS AND TILE ROOF.—Cost per estimates, $1,050.00. Annual Depreciations, 1 1-6 per cent. walls, 1 2-3 per cent. roof. Annual Depreciation equals $13.31.

CONCRETE WALLS AND TIN ROOF.—Cost per estimates, $958.00. Annual Depreciations, 1 1-6 per cent. walls, 4⅛ per cent. roof. Annual Depreciation equals $14.73.

CONCRETE WALLS AND SLATE ROOF.—Cost per estimates, $967.00. Annual Depreciations, 1 1-6 per cent. walls, 1 per cent. roof. Annual Depreciation equals $11.07.

CONCRETE WALLS AND SHINGLE ROOF.—Cost per estimates, $925.00. Annual Depreciations, 1 1-6 per cent. walls, 8¼ per cent. roof. Annual Depreciation equals $16.96.

FRAME WALLS AND TILE ROOF.—Cost per estimates, $831.00. Annual Depreciations, 2 8-10 per cent. walls, 1 2-3 per cent. roof. Annual Depreciation equals $22.28.

FRAME WALLS AND TIN ROOF.—Cost per estimates, $739.00. Annual Depreciations, 2 8-10 per cent. walls, 4⅛ per cent. roof. Annual Depreciation equals $22.87.

FRAME WALLS AND SLATE ROOF.—Cost per estimates, $748.00. Annual Depreciations, 2 8-10 per cent. walls, 1 per cent. roof. Annual Depreciation equals $18.62.

FRAME WALLS AND SHINGLE ROOF.—Cost per estimates, $706.00. Annual Depreciations, 2 8-10 per cent. walls, 8¼ per cent. roof. Annual Depreciation equals $24.51.

In figures of cost and in estimating depreciation, no account is taken of interior work nor of inside wear and tear; these figures relate only to outside walls and the roof.

From the foregoing we select for illustration three types of construction:

		Cost.	Depreciation.		Per Cent.
1.	Concrete Walls, Tile Roof.....	$1,050	$13.31	equals	1 27-100
2.	Brick Walls, Slate Roof.......	1,225	13.62	equals	1 11-100
3.	Frame Walls, Shingle Roof....	706	24.51	equals	3 47-100

Assume cost of land ($500) and interior work ($1,500) to be $2,000 additional in each case, and that each house rents for 10 per cent. of the cost. Result at end of twenty years:

1. Concrete Walls, Tile Roof. Value $3,050. Rents for $305.00 per annum. $305.00 x 20 years, equals $6,100.

Charge $13.31 x 20 equals	$266.20	Depreciation.
Charge 30.50 x 20 equals	610.00	Taxes, say 1 per cent. on value.
Charge 24.29 x 20 equals	485.80	Ins. Premiums on $2,550, being average for three occupancies given. Page 259.
	$1,362.00	

From $6,100, twenty years' income, deduct $1,362 charges, leaving $4,738; same divided by 20 gives $236.90 per annum and represents 7 77-100 per cent. interest.

2. Brick Walls, Slate Roof. Value $3,225. Rents for $322.50 per annum. $322.50 x 20 years, equals $6,450.

Charge $13.62 x 20 equals	$272.40	Depreciation.
Charge 32.25 x 20 equals	645.00	Taxes, say 1 per cent. on value.
Charge 25.96 x 20 equals	519.20	Ins. Premiums on $2,725, being average for three occupancies given. Page 259.
	$1,436.60	

From $6,450, twenty years' income, deduct $1,436.60 charges, leaving $5,013.40; same divided by 20 gives $250.67 per annum and represents 7 77-100 per cent. interest.

3. Wood Walls, Shingle Roof. Value $2,706. Rents for $270.60 per annum. $270.60 x 20 years, equals $5,412.

Charge $24.51 x 20 equals	$490.20	Depreciation.
Charge 27.06 x 20 equals	541.20	Taxes, say 1 per cent. on value.
Charge 60.00 x 5 equals	300.00	For outside painting every 4 years.
Charge 20.00 x 20 equals	400.00	For extra cost of heating.
Charge 44.26 x 20 equals	885.20	Ins. Premiums on $2,206, being average for three occupancies given. Page 259.
	$2,616.60	

From $5,412, twenty years' income, deduct $2,616.60 charges, leaving $2,795.40; same divided by 20 gives $139.77 per annum and represents 5 16-100 per cent. interest.

In a brick, stone or concrete house the reduction of concealed spaces in the walls is a material advantage in excluding rats and other vermin.

The insurance cost is also a factor of considerable moment in determining the ultimate economy of good construction, and in order to set this forth fairly we have averaged rates for different constructions in Southern towns of first, second and third-class fire protection, also towns with no protection, for the three main divisional occupancies, being (a) dwellings; (b) stores; (c) factories, selecting for the latter, sixteen classes of factories common in the South. All of these rates are basis figures—that is, without any charge for interior or protective defects, or charge for exposure of other buildings. Touching the exposure charge it may be well to state, in passing, that such is notably less to brick, stone or concrete buildings with metal, tile or slate roofs than to frame, shingle roof buildings, for the obvious reason that the former are much less likely to be ignited by a burning building near by than the latter. The insurance rates given assume also that standard chimneys built from the ground exist in the buildings, otherwise an additional charge of about 11 per cent. applies to dwelling rates and from 10 cents to 25 cents per $100 insurance in the case of stores and factories. Our estimates show an excess cost of $33 for a chimney with one flue, built from the ground, over a hung flue. In an ordinary frame dwelling insured for $1,000 the difference in premium would pay the extra cost in about the same number of years (33) and in proportionately less time, according to increased value.

The insurance rate (and charge) on a building extends naturally to the contents as well. In many instances the value of the contents exceeds the cost of the building itself, so for the purpose of counting the cost of poor construction it is proper to apply the insurance cost to what is in the building as well as to the building itself. Therefore, it follows that a building justifying a low insurance rate is additionally better for the builder if he is to be the occupant, and if built to be let, the feature of a minimum rate will make it rent more readily and to better advantage.

On the score of annual insurance charge on building and contents the advantage of good construction may be worked out as in the following illustrations for (a) dwelling; (b) store; (c) factory.

Reverting to the building we have assumed, add $1,500 as elsewhere for the value of interior work (excluding the land), whence we get values for buildings for the three types, as follows:

Concrete Walls and Tile Roof	$1,050	plus	$1,500	equals	$2,550
Brick Walls and Slate Roof	1,225	plus	1,500	equals	2,725
Frame Walls and Shingle Roof	706	plus	1,500	equals	2,206

Assume each type to be occupied (a) as dwelling, with furniture requiring $1,500 insurance; (b) as store, with stock needing $10,000 insurance, and (c) as factory, with machinery and other contents wanting $15,000 insurance. From the tables of average rates we calculate insurance premiums as follows:

TYPE No. 1

(Reinforced Concrete Walls and Tile Roof)

		Rate Per Cent	Premium
DWELLING:			
Building	$2,550.00	@ .49½	$12.63
Contents	1,500.00	@ .49½	7.42
	$4,050.00		$20.05
STORE:			
Building	$2,550.00	@ .95	$24.23
Contents	10,000.00	@1.01¼	101.25
	$12,550.00		$125.48
FACTORY:			
Building	$2,550.00	@1.41¼	$36.01
Contents	15,000.00	@1.41¼	211.88
	$17,550.00		$247.89

TYPE No. 2

(Brick Walls and Slate Roof)

		Rate Per Cent	Premium
DWELLING.			
Building	$2,725.00	@ .49½	$13.49
Contents	1,500.00	@ .49½	7.42
	$4,225.00		$20.91
STORE:			
Building	$2,725.00	@ .95	$25.89
Contents	10,000.00	@1.01¼	101.25
	$12,725.00		$127.14
FACTORY:			
Building	$2,725.00	@1.41¼	$38.49
Contents	15,000.00	@1.41¼	211.88
	$17,725.00		$250.37

TYPE No. 3

(Frame Walls and Shingle Roof)

		Rate Per Cent	Premium
DWELLING:			
Building	$2,206.00	@ .882	$19.46
Contents	1,500.00	@ .882	13.23
	$3,706.00		$32.69

STORE:			
Building	$2,206.00	@2.75	$60.67
Contents	10,000.00	@2.68¾	268.75
	$12,206.00		$329.42
FACTORY:			
Building	$2,206.00	@2.38¾	$52.67
Contents	15,000.00	@2.38¾	358.12
	$17,206.00		$410.79

DWELLING

Type		Cost of Bldg.	Premium on Bldg. & Cont.
No. 1.	Concrete Walls and Tile Roof	$2,550.00	$20.05
No. 2.	Brick Walls and Slate Roof	2,725.00	20.91
No. 3.	Frame Walls and Shingle Roof	2,206.00	32.69

Difference in premium alone will pay increased cost of Type No. 1 over Type No. 3 ($344.00), in twenty-seven years.

Difference in premium will pay increased cost of Type No. 2 over Type No. 3 ($519.00), in forty-four years.

STORES

Type		Cost of Bldg.	Premium on Bldg. & Cont.
No. 1.	Concrete Walls and Tile Roof	$2,550.00	$125.48
No. 2.	Brick Walls and Slate Roof	2,725.00	127.14
No. 3.	Frame Walls and Shingle Roof	2,206.00	329.42

Difference in premium will pay increased cost of Type No. 1 over No. 3 ($344.00), in two years.

Difference in premium will pay increased cost of Type No. 2 over Type No. 3 ($519.00), in three years.

FACTORY

Type		Cost of Bldg.	Premium on Bldg. & Cont.
No. 1.	Concrete Walls and Tile Roof	$2,550.00	$247.89
No. 2.	Brick Walls and Slate Roof	2,725.00	250.37
No. 3.	Frame Walls and Shingle Roof	2,206.00	410.79

Difference in premium will pay increased cost of Type No. 1 over No. 3 ($344.00), in a trifle over two years.

Difference in premium will pay increased cost of Type No. 2 over Type No. 3 ($519.00), in 3¼ years.

We believe this disproportion between initial saving and incidental expense later—permanent and continuous cost and actual loss—could be carried on and set forth indefinitely. Cheap plastering on furring strips and wood lath, with frequent restoration of fallen ceilings and blemished, cracked walls—wood window frames that shrink away from studding, with consequent drafty rooms—lath and plaster partitions (harboring rats and vermin) in place of tile. Many interior features of inferior material or construction exist, the cost of which in comfort and health is great, but not readily quotable in money value.

These suggestions and figures plainly indicate that insurance companies are doing all in their power to encourage good construction and the safeguarding of hazards, by making radical and substantial reduction in premium rates for superior conditions. We submit that we are employing our best efforts in that direction. May we have your active co-operation to the same end?

Important as all this is to us, our interest is almost trivial compared with that of your clients. From every quarter recitals reach us of men and women either roasted alive in flimsily built hotels, theaters, stores and factories, or crushed on the ground below after jumping from upper windows to escape a worse death, to say nothing of the suffering of horses, cattle and other dumb creatures destroyed by thousands in fire-trap buildings. The 1915 fire waste of this country exceeded $180,000,000. It is a safe and sober statement that half of this would be saved by the use of incombustible materials for walls and roofs, and by substantial chimneys and safe heating arrangements. Prevention is better than cure.

THE COST OF CONCRETE BUILDINGS

It has been a common method to estimate the approximate cost of a building by either the square foot of floor or the cubic foot of space enclosed. In a paper published in The Engineering Record, Jan. 16, 1909, Leonard C. Wason, president of the Aberthaw Construction Co., Boston, presents numerous comparative costs obtained through his own experience and states as his conclusion that "after making this comparison he is convinced that neither method is accurate enough to put much reliance on, but that the square foot method is a little safer than the other." Four of the tables from his paper are presented herewith. In each case the total cost includes masonry and carpentry work without interior finish or decorating, plumbing and heating. The effort has been made to put the buildings upon a comparative basis as regards the amount of work done on each.

The first table consists of the total cost of actual contracts executed. The second table consists of bona fide bids on complete buildings on which Mr. Wason's company were not the lowest bidders, but where the difference was not, as a rule, very great. The third and fourth tables are bona fide bids on work by another contractor whose experience was similar to that of Mr. Wason's. As a rule, cubic foot measurements are given in cents only, seldom being carried to any closer subdivision. In reference to Table 4 on second class buildings, it will be noted that for the largest building a variation of one cent per cubic foot amounts to over $28,000, while the smallest one in the list amounts to only a little over $5,400. Again, on the last three items, the cubic foot price is practically identical, while the square foot measurements corresponding, vary by more than 100 per cent. with no easily apparent reason in the design.

In Table 3 another discrepancy is noticed. In the first and the last items, the highest and the lowest per cubic foot as well as per square foot, are on office buildings of similar type which were within one mile of each other where there is no apparent reason for such discrepancy in the design or difficulty of access in the erection of the building. It is recommended by Mr. Wason that very little reliance be placed upon this class of estimates.

Table 1.—Cost of Fireproof Completed Contracts

KIND OF BUILDING.	Job cost.	Volume in cu. ft.	Floor area in sq. ft.	Unit cost Per cu. ft.	Unit cost Per. sq. ft.
Offices and stores......	$181,194	1,365,830	90,474	$0.133	$2.00
Offices and stores......	61,646	496,780	39,840	.124	1.545
Factory...............	12,774	112,440	7,519	.114	1.70
Factory...............	44,652	746,674	49,546	.060	.902
Factory...............	39,830	312,000	24,960	.127	1.60
Garage...............	10,436	156,198	10,806	.085	1,23
Filter...............	19,993	149,250	19,208	.134	1.04
Fire station...........	6,757	44,265	2,982	.153	2.26
Observatory..........	3,625	9,734	657	.373	5.45
Filter...............	20,076	59,991	5,243	.333	3.82
Highest...............	.....	......	.....	.373	3.82
Lowest...............	.....	......	.....	.06	.90
Average...............	.....	......	.....	.138	1.72

Table 2.—Cost of Fireproof Complete Buildings

KIND OF BUILDING.	Job cost.	Volume in cu. ft.	Floor area in sq. ft.	Unit cost Per cu. ft.	Unit cost Per. sq. ft.
Storehouse............	$141,755	1,714,448	168,696	$0.0827	$0.84
Hospital.............	60,800	703,692	57,654	.0865	1.05
Office building	61,646	496,780	39,840	.124	1.545
Cold storage	200,051	1,535,000	154,000	.13	1.30
Factory..............	19,292	212,400	15,000	.091	1.28
Factory..............	141,529	1,327,868	106,022	.107	1.335
Storehouse...........	76,796	1,140,000	146,000	.0685	.575
Mfg. building	91,377	1,380,500	90,240	.067	1.01
Office...............	136,880	693,840	56,552	.197	2.42
Factory..............	13,064	105,600	8,800	.124	1.485
Factory..............	75,604	1,211,364	74,604	.0625	1.01
Factory..............	23,332	180,000	16,394	.129	1.42
Highest..............	.....	......	.....	.197	2.42
Lowest..............	.....	......	.....	.0625	.575
Average..............	.....	......	.....	.1088	1.27

Table 3.—Cost of Fireproof Buildings

KIND OF BUILDING.	Job cost.	Volume in cu. ft.	Floor area in sq. ft.	Unit cost	
				Per cu. ft.	Per. sq. ft.
Office building	$70,690	441,000	35,854	$0.159	$1.97
Cold storage	132,365	1,016,400	101,640	.13	1.30
Hospital	44,451	348,320	34,832	.127	1.27
Hospital	51,574	414,732	29,838	.124	1.73
Bank	65,580	533,750	.....	.123	....
Masonic	180,197	1,479,456	.....	.122	....
Warehouse	31,280	259,700	24,500	.120	1.28
Garage	59,105	497,420	.....	.118	....
Warehouse	275,723	2,597,000	212,000	.106	1.30
Hotel	220,646	2,116,106	.....	.104	....
Hospital	49,724	485,789	38,247	.100	1.30
Office	25,151	264,687	.....	.095	....
Cold storage	82,711	909,240	66,745	.091	1.24
Club	43,586	513,808	.....	.085	....
Office	60,003	501,575	67,400	.084	1.12
Highest	.....	......	.....	.159	1.97
Lowest	.....	......	.....	.084	1.12
Average	.....	......	.....	.113	1.39
Variation, high and low.	.....	......	.....	53.8%	57.0%

Table 4.—Cost of Mill Construction or Second-class Building

KIND OF BUILDING.	Job cost.	Volume in cu. ft.	Floor area in sq. ft.	Unit cost	
				Per cu. ft.	Per. sq. ft.
Mill	$66,516	544,788	44,172	$0.122	$1.51
Warehouse	337,000	2,808,850	.....	.12	....
Mill	113,288	1,271,300	129,920	.0891	.875
Storehouse	101,098	1,714,448	168,696	.059	.60
Mill	90,703	1,622,128	152,200	.056	.60
Mill	72,048	1,331,200	83,200	.054	.865
Mill	85,754	1,752,609	81,500	.048	1.05
Mill	122,128	2,641,000	98,059	.046	1.25
Mill	94,341	2,036,731	174,000	.046	.542
Mill	129,405	2,867,535	157,730	.045	.82
Highest	.....	......	.....	.122	1.51
Lowest	.....	......	.....	.045	.542
Average	.....	......	.....	.069	.90

—From The Engineering Record, Feb. 27, 1909.

GYPSUM AS A FIREPROOFING MATERIAL

Gypsum is used as a fireproofing material in the form of blocks, plaster board and plaster on metal lath. The results of considerable experience on its application in these three forms are available and have recently been brought together by Mr. H. G. Perring in a pamphlet, which the National Fire Protection Association is sending out. Preceding the data relating to actual construction with the material is information regarding the fire-resisting qualities of gypsum from which the following notes have been taken:

Plaster of Paris is made from gypsum, which is a sulphate of lime; chemically, a hydrous calcium sulphate, the formula of which is expressed as $Ca\ SO_4 + 2\ H_2O$. Interpreted, this formula may be expressed as 32.5 per cent. by weight of calcium and 46.6 per cent. sulphuric acid chemically compounded and holding 20.9 per cent. of water of crystallization. Plaster of Paris is made by calcining the gypsum rock to drive off part of the water of crystallization. This material has the valuable quality of taking up water and, by a crystallizing process, becoming again converted into gypsum.

Gypsum is a soft mineral, ranking number 2 in a scale of 10 in Moh's scale of hardness. It has a specific gravity of 2.32 and weighs 145 lbs. per cubic foot.

Plaster of Paris has a specific gravity of 1.81, but upon setting with water returns to a specific gravity of 2.32.

Delicate experiments have shown that plaster in setting neither contracts nor expands.

Plaster has been generally recognized as a fireproofing material in Europe for many years, Mr. Perring states, and is today used almost exclusively for partitions and to a great extent for floors in France and Germany, while in England many of the government buildings, including the newer portions of Windsor Castle, have partitions of plaster block. In America, despite the prejudice against plaster fireproofing, over 1,000 of the large fireproof buildings of the country have been fireproofed either wholly or in part by plaster in the form of plaster blocks, a large number having plaster floors. Metal lath and plaster for partitions has been used to a great extent, and in the smaller buildings plaster board and plaster.

Mr. Perring discusses at some length the various fire test requirements and gives a list of fire tests of gypsum products. In summarizing, Mr. Perring treats the various classes of gypsum products but only the results in two classes are repeated here. Plaster blocks in 18 tests of fire and water for periods of from 1 to 2 hours stood successfully, resisting the passage of flame, smoke or water, and were stable and strong after test. These tests have shown that the effect of a fire of 2 hours' duration is but little greater than that of 1 hour. The effect of one hour of high temperature fire is to recalcine the block to a depth of about ⅜ in., while 2 hours will carry the recalcination to a depth of ¾ inch. The effect of a stream from a fire hose is to wash off this recalcined material. In seven tests of metal lath and gypsum plaster the effect of high temperature fire for 1 hour was to recalcine the plaster as in the blocks to a depth of about ⅜ to ½ in. The application of water from a fire hose will wash off this recalcined material and occasionally erode the material sufficiently to expose patches of the metal.

Few fires have occurred in buildings in which plaster has been used for fireproofing, but the following are cited as indicating more than a laboratory test:

On Feb. 6, 1906, at 9 o'clock a fire occurred in the Engineering Building in the University of Pennsylvania, Philadelphia. The fire spread so rapidly that a second alarm was sent in 15 minutes after the start of the fire. Two fire alarms brought out nine engine companies, which played 15 streams of hose on the fire until 2 a. m., at which time the fire was considered past the dangerous point, and all but one engine went home, the remaining engine playing a stream of water upon the smoking embers until 7 a. m., when the fire was pronounced completely out. The building was erected in 1892, had brick exterior walls and an interior construction known as mill, or slow-burning construction; that is, the column and girders were of heavy yellow pine timber and the floor of 3-in. yellow pine. The trim of the rooms was also of yellow pine; a structure well calculated to burn with intense heat when the fire was well started. The partitions were fire-proof, being made of gypsum plaster blocks 3-in. thick. Despite the intense heat and the many tons of water thrown into the building the partitions remained intact and would have required no repairs beyond replastering to fit them for use again. These partitions prevented the spread of the fire and saved a considerable portion of the building from any damage whatsoever, preventing the loss of a valuable engineering library, which was in a room completely shut off from the fire by the gypsum tile partitions.

On March 4, 1910, a fire occurred in the Alwyn Court fireproof apartment house, New York City. The interior columns were fireproofed with 2-in. U. S. Gypsum Company's composition plaster blocks with an air space between blocks and columns. Partitions were of 3-in. plaster blocks set in wood frame work (wood door "bucks"). The hallways were formed of 3-in. composition blocks with kalamein doors to apartments. Many of the rooms contained an unusual amount of lumber in the form of wood trim, parquet flooring, side and ceiling paneling and other decorative woodwork. The following extract is taken from the report of the New York Board of Fire Underwriters:

"The ninth and tenth floors in the duplex apartment were gutted except the northerly rooms of the tenth, which were badly damaged. The dining room and reception hall of west apartment on eleventh floor were practically gutted, with heavy damage in kitchen and moderate damage in other rooms. In the west apartment on twelfth floor the dining room, reception hall and living room, including salon, were practically gutted; considerable damage in kitchen and maids' room; only moderate damage in northerly rooms. The west apartments immediately below the floor, where the fire started, had considerable water on ceilings, walls and floors; part of ceiling plaster had fallen off in a few rooms. There was no fire and but little water damage in easterly apartments, including those above the eighth. There seems to have been no structural damage to the steel frame or its fireproofing; the lower flanges of floor beams were protected only by plaster finish, which fell off and exposed the flanges to considerable heat, but no deflection of beam is apparent. The channel shaped steel lintels over dining room windows were softened by the heat and deflected, particularly those on the twelfth floor. The 3-in. plaster block partitions are intact, except around the doorways, where they were supported by wooden frame work, which was entirely burned away and caused the blocks to fall."

Analyzing the special features of gypsum plaster in general, which make the material desirable as fireproofing, Mr. Perring draws the following conclusions:

1. Low heat conductivity is an essential point. In partitions heat is not conducted through to set fire to furnishings on the opposite side. In the protection of structural steel work the steel is protected from the weakening action of heat. The heat penetrates the plaster at such a slow rate that in fires of ordinary duration the metal would hardly get warm.

2. Tests and experiments have failed to indicate any appreciable expansion of plaster under heat action.

3. Materials of a nature that expand under heat readily contract when water is applied to the heated surface. This contraction is often so severe as to cause the bursting of the material. Plaster

partially recalcines under high heat action and the subsequent application of water removes this recalcined portion, but generally will withstand severe water application, there being no indication of bursting.

4. Any material to be used for fireproofing must not burn or support combustion. Plaster is incombustible.

5. Lightness is essential in fireproofing, as the fireproofing at best is dead load on a building and plays no part in the support of the structure. Plaster is the lightest practical fireproofing material.

6. Plaster fireproofing has sufficient strength for use in partitions and column covering, and in fires will stand up reliably against the impact of fire streams.

7. Plaster is adaptable to any form of construction. Where used in slabs they are readily sawed or cut to fit any desired location and the use of the material in the plastic state will cover any possible condition of construction.

8. The desirable fireproofing material is one that combines all the fireproofing features with low cost. Plaster is low in cost.

Trim can be nailed to plaster fireproofing without the use of wood blocks or grounds, saving the cost thereof and omitting combustible material from the building. Plaster blocks or boards are true and even and reduce the cost of plastering to a minimum. The blocks are made of pure gypsum and wood fibre.

Changes in partitions can be made with a minimum of dirt and discomfort. Where a door is to be cut in a partition a hole is bored through with an auger, a keyhole saw inserted and sufficient cut made to insert a large saw, after which the opening is neatly cut, the frame inserted and the trim covers the edges so that no plastering beyond the pointing up around the door buck is necessary, and the decorations are not destroyed.

The blocks should be laid with core holes horizontal, with joints broken vertically. They should be laid in gypsum mortar consisting of one part gypsum plaster mortar and three parts sand. The joints should not exceed ½ in. in thickness.—From The Engineering Record, Dec. 3, 1910.

The Underwriters' Laboratories report that: Non-bearing corridor and room partitions for fire-proof office buildings, hotels, apartments, and buildings of this class, made of listed types of gypsum blocks and laid with vertical joints broken in gypsum cement mortar containing not to exceed 3 parts of sand, coated on each side with the same material at least ½-inch in thickness, and set on non-combustible foundations, are standard for corridor and room partitions not exceeding 13 and 17 feet in height, respectively, for 3 and 4-inch thicknesses of block, in dry locations where the temperatures do not exceed 200 degrees Fahr., but not for enclosures to stairways, elevators, or vertical communications where full protection is required.

TYPICAL SPECIFICATIONS FOR STUCCO ON METAL LATH*

Foreword

The merits of the stucco house are now so well recognized that arguments in its favor seem to be trite. It is assumed that the prospective builder and his architect want a stucco exterior and realizing that when built, the house will look as substantial as stone, brick or solid concrete, they want a structure that will age slowly and gracefully through decades—not fail perceptibly from year to year.

This specification is offered with this realization promised but it must be borne in mind that poor work is dear at any price. A faithful observance of every detail will give results gratifying to the architect and satisfactory to the owner.

Metal Lath is recommended because wood lath absorbs moisture required by the mortar. Wood lath drys out and shrinks away from the plaster following which the alternate shrinkage and swelling resulting from moisture causes unsightly cracks and finally failure. Wood lath, also, increases the fire risk and it will harbor vermin.

Metal lath in combination with cement plaster is "reinforced concrete" and will insure an unbroken surface,—to be assured of which is at least an uncertainty when the plaster is applied direct to a wall set up in block form. The air space afforded by metal lath construction is the most efficient insulation.

A careful following of this specification will absolutely give a construction economical and enduring.

Framing and General Construction

Flimsy construction in framing is false economy. The best will prove cheapest. The studs spaced 12" between centers wherever possible, should be run entirely from foundation to the rafters without any intervening horizontal grain in the wood. These studs shall be tied together just below the second story joists by a 6" board which shall be let into the studs on their inner side, so as to be flush and securely nailed to them. This board will also act as a sill for the second story joists, which in addition will be securely spiked to the sides of the studs. At two points between the foundation and the eaves, brace between the studding with 2"x3" bridging placed horizontally but with the faces of the bridging inclined in alternate directions in adjacent spaces.

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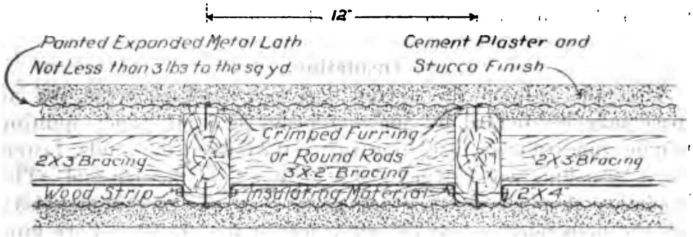
* Recommended by Associated Metal Lath Manufacturers, Youngstown, Ohio.



Detail Showing Section of Exterior Wall

All roof gutters should be fixed and down spouts put up before the plastering is done; the down-spouts should be temporarily placed about a foot from the wall so there will be no break in the plastering where they are to be finally fixed.

Wood copings or rails for tops of parapets, balustrades, etc., are not so good as cement for they may curl up, warp, check, crack, and in various ways fail to do what they should—KEEP WATER FROM GETTING BEHIND THE PLASTER. This also applies to brick chimneys, which, when plastered, should have wide and tight caps of concrete or stone to prevent water running behind the plaster.

If only wood sills are used, they should project well from the face of the plaster and should have a good drip; either by being placed with a downward slant or by a groove rabbeted in the under side of the sill near enough to its edge that it will not be covered by plaster. THE DRIP IS AN ESSENTIAL OF GOOD STUCCO CONSTRUCTION THAT CAN NOT BE SLIGHTED. IT MUST BE USED TO PREVENT WATER GETTING BEHIND THE PLASTER.

Lath and plaster should not be carried all the way down to the ground; this same restriction applies to brick or stone.

Care should be taken that all trim be placed the proper distance from the studding or furring to show its right projection after the plaster is on. It is a common mistake to allow too little for the lath and plaster, with the result that mouldings which should project from the face of the wall are back from it or partly buried under the plaster, thus missing the effect desired. About 1½" should be allowed for the lath and plaster, making sure that the projection of the moulding to show when finished is not measured in as part of this thickness.

Furring

Use painted or galvanized steel rods or painted or galvanized crimped furring. One-quarter inch is best and it should not be over one-half inch at the most. This furring is to be applied along the face of the studding with galvanized staples.

Insulation

After the lath on the outside has been back-plastered the air space may be divided by applying heavy building paper, quilting, felt or some suitable insulating material between the studs, fastening it by nailing wood strips over folded ends of the material. This insulation should be so fastened as to clear the 2" bridging, leaving the preponderance of the air-space on the outside. Care must be taken to keep the insulating material clear of the outside plaster and to make tight joints against the wood framing at the top and bottom of the spaces and against the bridging where the 3" face intercepts.

Corner Bead

If corner bead is not used, there should be 6" strips of metal lath bent around the corners and stapled over the lathing unless the sheets of metal lath as applied are folded around the corners.

Even though corner bead is used, it is a good precaution to bind the corners in this way and apply the corner bead over the strips of lath.

Lathing

The lath shall be painted to protect it until it can be applied and covered with Portland cement plaster. Care should be taken not to expose the lath to the weather while it is lying about the building.

Use metal lath weighing not less than 3 lbs. per square yard, spaced at 12" centers and fastened horizontally over the furring strips with galvanized staples 1¼ x No. 14 gauge. The sheets between furring are to be tied with No. 18 gauge galvanized wire.

Plastering

Portland cement will protect metal from corrosion absolutely by reason of its moisture-resisting qualities. Calcined gypsum should not be used in combination with Portland cement, as the gypsum will destroy the productive quality in the cement; neither should it be used as a substitute for Portland cement. A gypsum plaster may repel moisture for a time, but Portland cement actually thrives on it.

It is not theory only that Portland cement will preserve iron or steel indefinitely; it has been well demonstrated that Portland cement stucco will endure in any habitable climate. The first and second coats should be of good thickness and the finishing coat should have with it a mixture of waterproofing. A total thickness of plaster of about 1½" is good practice.

It is aimed for the first and second coats to get a Portland cement mortar with as little lime in it as will make it work properly. Clean long winter cattle hair should be used.

For the first and second coats and back-plastering, mix in the following proportions:

Lime Mortar. 2 barrels of hydrated lime.
1 yard of clean sharp sand free from loam.
4 bushels of cattle hair.

Made up at least 3 days before using.

Cement Mortar. 2 parts of clean sharp sand free from loam.
1 part Portland cement.

Mix fresh in small batches as used.

The Lime Mortar and Cement Mortar should be mixed and tempered separately, measured carefully, equal parts of each and mixed well together.

In plastering over the face of the stud, the plaster should be forced well through the lath in order to fill entirely the space between the lath and the stud.

The back-plastering should be a heavy coat well troweled so that the lath is entirely enveloped. The finish coat may be done in a way to get any one of the many surfaces which give stucco its charm; this coat should contain no lime as it makes the wall more porous and if a lighter color is wanted than can be gotten with ordinary cement, a white Portland cement should be used.

The waterproofing acceptable to the architect should be mixed with the last coat of the exterior according to directions given by the waterproofing manufacturer. The lathing and plastering on the inner side of the wall need not differ from ordinary practice.

The exterior plaster must not be allowed to set rapidly; if necessary, hang a curtain in front of the wall, of burlap or other material that can be kept moist for a couple of days. Stucco should never be applied when the temperature is below freezing.

Stucco on Brick

In applying stucco over brick chimneys a ½" painted or galvanized steel furring strip not lighter than 22 gauge should be fastened to the brick at 12" centers with galvanized staples 2" x No. 9 gauge driven into the mortar joints. The lath is fastened to the furring with No. 18 gauge galvanized wire, run through under the furring and the same material used for lacing the ends of the sheets together between furring strips.

The same mixture for plaster is recommended for this work as on the metal lath on studding. Before plastering, the brick should be well wetted to prevent its absorbing the moisture from the plaster and the first coat should be forced through thoroughly so that the entire space back of the lath is filled with the Portland cement plaster and the lath enveloped.

ASBESTOS*

Asbestos is one of the most peculiar and marvelous productions in organic nature. Called by mineralogists, asbestus, the name in its Greek form signifies unquenchable, inextinguishable, inconsumable.

It has been called a "mineralogical vegetable." In mineralogy, three minerals are classified under the term "asbestos," namely, antophyllite, amphibole and serpentine.

1st. Antophyllite, which is not used commercially.

2d. Amphibole or hornblende asbestos. This includes various varieties, among which are actinolite and Italian asbestos.

3d. Serpentine asbestos, which has three fibrous forms, namely, picrolite, soapstone or talc and chrysotile. The chrysotile asbestos is a variety found in the Canadian deposits and is the only variety which is of much economic value.

In appearance and mineralogical character these varieties are somewhat different, while in chemical composition they are very similar. The amphibole varieties being silicate of lime and magnesia and alumina, while serpentine is a hydrated silicate of magnesia. The following is about the average chemical composition of the Canadian chrysotile asbestos, viz.:

Silica	40%
Magnesia	42%
Ferrous oxide	3%
Alumina	1%
Water	14%
	100%

The chemical analysis is important in determining the value of an asbestos deposit, because all fibres capable of being spun must analyze about as stated. The percentage of water has apparently much to do with the strength, silkiness and flexibility of the fibre. The Canadian chrysotile asbestos always seems to contain not less than 13 per cent of water, while all the harsh and more brittle fibres of the other types of asbestos contain little water, varying from 1 per cent to 5 per cent consequently they are of little or no value.

While asbestos in one or other of its varieties has been found in many states of the United States, in Italy, South and Central America, China, Japan, Australia, South Africa, and other parts of the world, none of these deposits so far have proved to be of much economic value, or are so located that they cannot be worked profitably.

About 80 per cent of the world's production of commercial asbestos is being supplied from the Canadian deposits. Russia is the next largest producer of commercial asbestos to Canada.

The Canadian developed deposits of asbestos are located south of the St. Lawrence river in the Eastern Townships of the Province of Quebec—one of the largest being four miles from Danville, in the County of Richmond, on the line of the Grand Trunk Railway. The others being situated at Thetford Mines, Black Lake, Robertson and East Broughton in the County of Megantic, on the line of the Quebec Central Railway.

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* Abstract of an address by L. R. Hoff before the Fire Insurance Society of Philadelphia.

The deposits were discovered about 1877 and the gradual development has taken place since then, until the total shipments for the year ending December 31, 1910, amounted to 80,000 tons, valued at over two and a half million dollars.

The chrysotile asbestos found in these deposits occurs as a fibrous silky product, lying in narrow veins in a mass of serpentine rock. The veins are found in every direction throughout the entire mass and often intersect each other at all angles. The general tendency of the veins, however, is more or less parallel with a slight dip downwards.

The fibres lie at right angles to the walls of the veins and vary in length from two and one-half inches to one-eight inch or less. The asbestos in the vein has a marked wavy lustre of a greenish tint, but when the silky fibres are separated they are pure white.

Mining.—While generally referred to as "asbestos mining," the Canadian developed deposits are nearly all worked as open quarries. As practically the entire mass of rock has to be removed, quarrying is the cheapest method. Unless the deposits are very rich in the longest grades of fibres, underground mining is too costly.

The different quarries vary in size and shape. Some of the larger ones, at present worked, are from 1,000 to 1,500 feet in length, with an approximate average width of 300 to 400 feet, and in some instances, a depth of 200 feet. So far, the depths of these Canadian deposits have not been finally determined, but asbestos has been found at a depth of 400 feet. It is nearly impossible to test by diamond drillings, owing to the fibrous nature of the rock.

The quarrying is usually carried on by a series of benches or terraces from the top to the bottom of the quarry. Rock drills, operated by compressed air, are usually used for drilling. The depth of holes drilled range from eight to fifteen feet, according to conditions.

The holes are filled with dynamite and exploded by electric batteries. The larger pieces of sepentine rock resulting from blasts are again drilled and exploded by similar process. After the rock is thus broken up, it undergoes a hand-sorting process. The pieces of rock containing veins of one-half inch or more in length are picked out and the longer fibres separated by "hand combing." The rock containing the shorter fibres is shovelled into boxes or skips to be sent to the mills for mechanical separation. The dead or barren rock is sent to the dumps.

Sorting.—What is known as No. 1 Crude and No. 2 Crude is hand picked, sorted and dressed. No. 1 being fibres of three-quarter inch and over in length. No. 2 from five-sixteenth inch to three-quarter inch in length. The roughly picked longest veins from the pits are broken down by hammers and passed over screens in order to get rid of the rock particles and the grading as No. 1 and No. 2 is done by hand.

The rock containing the shorter veins is sent to the mills for automatic, mechanical separation, by passing through a series of crushing rollers.

The problem of separating or extracting the fibres from the rock by a mechanical process, without unduly injuring the fibres, has been gradually solved, until it is now possible to get them free from grit and particles of rock.

The rock from the dumping cars is delivered into ore bins or slides, from which it is fed into crushers. The first crushers are usually of large capacity, with feed opening from 24" x 36" to 30" x 15", so that large pieces of rock can be fed in. From the first set of crushers the rock passes to a second and sometimes a third set to reduce the size. The serpentine rock usually splits in the crushers along the line of the asbestos vein. Thus, considerable asbestos is separated from the rock in the crushing, but the fibres are not opened up. As the rock is frequently wet, it is necessary to dry it before the fibres can be opened up and separated from all the rock particles.

From the crushers, the rock passes through driers of various description, heated by hot air, steam, etc.

From the driers, the material is sometimes carried to crushing rolls or is passed direct to some form of fiberizer. The previous crushings have liberated the asbestos veins from the rock, but fiberizing machines are required to open up the individual fibres. The fibres are separated by means of air currents, created by the fast revolving beaters which quickly discharge the silky fibres, without injuring them.

The product coming from the fiberizers consists of asbestos fibre and quantities of pulverized rock. The next process is the separation of the fibres from the pulverized rock. This is accomplished by means of screens and suction fans. The material from the fiberizers, after going through revolving sizing screens, is delivered to flat vibrating screens, covered with wire cloth or perforated plates. These screens are vibrated and set at a slight angle, the vibrating movement causing the fibres to come to the top and the pulverized rock is shaken through the meshes of the screen. When the fibres have traveled to the lower end of the screens, they are sucked up through hoods by means of suction fans, which deliver the fibres into collectors, from which they pass into long cylindrical grading screens which separate them into different lengths required by the manufacturers and then bagged ready for shipment. The tailings produced in the milling are carried away either by narrow gauge railroads or belt conveyors.

From the reports published by the Department of Mines at Ottawa and Quebec for the year ending December 31, 1910, the percentages and values are about as follows:

Total rock mined, 2,000,000 tons.

Total asbestos produced, 100,000 tons.

Total rock milled, 1,500,000 tons.

Percentages of asbestos produced to tons of rock mined, 5 per cent.

Percentages of asbestos produced to tons of rock milled, nearly 7 per cent.

The remarkable qualities of asbestos have been known even before the Christian era. Pliny refers to it in his works and it was undoubtedly used by the Greeks for cremation cloths. It is also believed that from examination of the wrappings of mummies in good state of preservation, that asbestos cloth was used to some extent in this connection, but it is only within the last fifty years that it has been commercially considered and only in the last twenty years become such an important factor in engineering and industrial construction.

The value of asbestos is graded according to the length of the fibres and in exactly the same ratio are graded the value of the manufactured product. I do not mean by this that the products manufactured from the longest fibres constitute the greatest bulk of asbestos commerce. To the contrary, from the medium and short fibres, are made the greatest percentage of manufactured asbestos products.

Asbestos Yarns and Cloth.—The longest, and of course the most valuable, fibres are used in the manufacture of yarns and cloths for numerous purposes. The fibres are carded and spun into yarn in much the same manner as cotton and wool, but on specially designed machinery. It is made into yarns of different strengths and diameters and twisted into various plies, according to the requirements of the purposes for which they are to be used.

The spinning of asbestos, because of its lack of the microscopic barbs found on wool and other fibres, has presented great difficulties and only by bringing together all the talent of textile manufacturers, has it been possible to produce the splendid product of to-day.

These yarns are woven into cloths of various weights, thicknesses and density of weave, according to the mechanical purposes for which they are intended.

They may be plain or asbestos-metallic. The former being composed solely of asbestos; the latter consisting of asbestos yarn, twisted around the strands of fine brass wire, woven into cloth. The plain cloth is used for many purposes, the more important of which are rod and valve packings. For this purpose the cloth is coated, or as technically called, frictioned with rubber compound and rolled up to required diameters round, or calendered where square packing is required. These packings are furnished in coil, spiral or ring form, according to the requirements of the engineers and are thoroughly lubricated and graphited, ready for use when supplied to the trade.

The cloth with wire interwoven in the strands of asbestos is frictioned in the same manner as in the case of the packing above described and may be used flat for all jointing purposes and folded into gaskets for all sorts of conditions.

By the way of digression, asbestos in this field alone has made the use of high pressure and superheated steam a success. Its great heat-resisting properties successfully withstand the high temperatures, without in any way affecting its serviceability, whereas the old form of rubber, cotton and flax packings would soon be charred into uselessness.

Asbestos cloth, plain or wire interwoven, preferably the latter, is almost generally used as a fire barrier in the proscenium openings of stages, where it is raised or lowered mechanically or manually, sliding on wire ropes, run through rings on the sides of the curtains, being raised bodily into the gridiron above the stage. A theatre curtain properly constructed and installed, will be a positive barrier to the spread of flames from the stage and affords protection to life and property.

Use in Filters.—Asbestos is one of the greatest known filters and is used extensively in all filtering processes, either in fibre or cloth form, more especially as a fabric, because in this form it is more tractable.

Chemical plants use it in filtering acid solutions where organic fabrics would be destroyed.

It has made the many wonderful electrolytic processes possible. Here it is used as diaphragms in the cells or compartments.

Most of the large portable filters of potable waters are based on the use of asbestos. Water, no matter how discolored by dirt and sediment, can be made as clear as crystal by one or at the most two filterings. Further, asbestos cloth in one of the most prominent German types of filters, has been proved to greatly reduce the number of pathological bacteria, by straining them from the water passing through.

Asbestos cloth is made up into gloves, coats, trousers, leggins, etc., for the protection of workmen in electrical furnaces, blast furnaces, glass plants, etc. For domestic purposes, into pads for protecting table tops from hot dishes, palm covers for hot irons, stove polishers, etc.

Brake Linings.—Some three or four years ago, it was discovered that asbestos possessed unusually high frictional properties and its introduction into the lining of brakes, had a great deal to do with the increased efficiency of automobiles, as well as stationary machinery, such as hoists, cranes and other types of machinery, where friction clutches or brakes are used. It has unusual advantages over organic linings as well as iron, in that it withstands the temperature caused by the friction, without disintegrating, and is immune from destruction from water or oil.

The medium length fibres are formed by various processes into all forms required for the insulation of heated surfaces, such as pipes, boilers, heaters, air ducts, coilings, flues, stack linings, etc.

Felted Insulation.—In this form the fibres are felted together by natural felting process with the addition of sponge or certain inert cementitious materials, which in themselves, possess insulating values and are fire proof. These are used to give added mechanical strength. The material thus felted, is moulded into cylindrical half sections for pipes; sheets and blocks for larger surfaces and rolls where a flexible material is required.

Magnesia Insulation.—In this well-known form of insulation, asbestos fibres are moulded as a bond with carbonate of magnesia in proportion of 85 per cent magnesia carbonate and 15 per cent fibre, into forms as above described, with the exception of the rolls. Carbonate of magnesia is used because of its lightness and the fact that like sponge, etc., in combination with asbestos fibre, it produces a structure with an infinite number of dead air cells, the basic principle of all insulation.

Cellular Asbestos Insulation.—This form is built up from asbestos felt or paper, later described. The felts are corrugated through regular corrugating rolls and wound over a mandrel to the required thickness for pipe covering or laid up in sheets or blocks, fastened together by means of fire-proof glue, a silicious fire-proofing material.' These cellular products in the cylindrical form for pipe covering, may be formed with the cells running lengthwise with the section or circumferentially, the latter being the higher insulator, because each cell is closed against the adjoining one, preventing the free transmission of air and the loss of heat by radiation.

Other Forms of Insulation.—There are other common forms of insulating materials made from asbestos, which are known as ordinary moulded coverings composed of gypsum or plaster of paris, bounded together with fibre. These, however, are the older and more primitive forms and because of low insulating value and inefficient mechanical strength, when applied to heated surfaces, are being abandoned by the engineering profession.

Where a material to be moulded on the job is required, various forms of cements in dry form are furnished. These cements are composed of a percentage of asbestos fibre of length and quality according to the demands of the trade and price which it is desired to pay, mixed with cementitious fire-proofing materials, which require only the addition of water and can be applied and trowelled on in much the same manner as Portland cement.

In passing it might be interesting to state that engineering authorities generally concede that one inch of high grade asbestos pipe covering on 150 pounds steam pressure is capable of saving approximately 85 per cent of the loss caused by condensation as compared with bare pipes; two inches, 88 per cent; three inches, 90 per cent.

On superheat, it has been found that a covering applied to the pipes, consisting of rings of high grade insulation, three inches wide on eighteen centers, forming a one inch air space, over which are superimposed two layers, each one inch thick of regular pipe covering, finished with a thin coating of cement, has an efficiency of 88 per cent to 90 per cent.

Paper Felt.—There are certain grades of the shorter fibres which are used in the manufacture of paper felts. These fibres are mixed in a beater in very much the same way as wood pulp and other fibres, passed over a standard type of paper machine adapted to the handling of this particular fibre and made into felts of thicknesses from one one-hundreths of an inch up to one-eighth of an inch in thickness.

The paper felts are used as above described, in the manufacture of cellular asbestos insulation material, fire-proof paper for lining floors, partitions, etc., of frame buildings and in the manufacture of asbestos roofings. The short fibres are also mixed with certain cementitious materials and made into asbestos boards of various thicknesses and density, in practically the same manner as cardboard is made, on what is known as a board or wet machine. These card-boards vary in thickness from one thirty-second of an inch to one-half of an inch and are used for all forms of fire proofing, where contained between other members in construction and no great mechanical strength is required.

Roofing Material.—As above stated, certain grades of short fibres of asbestos are felted into paper, that is afterwards built up into asbestos roofing. For this purpose a specially selected superior grade of shorter fibres, free from grit, is used; made on a regular paper-making machine, into thin felts, which are saturated with a bituminous material.

For this purpose, the very best results are obtained by using a natural asphalt with non-volatile oils and it is these two basic materials on which the great value and durability of asbestos roofing depends.

Asbestos, as is generally conceded, is not subject to rot, rust or decay; therefore, it possesses all of the much desired requirements for a permanent roofing felt and all that it needs to give it an indeterminate life without cost of up-keep, is a proper waterproofing element. Compounded asphalts combined with highly volatile oils while they may be used in the manufacture of asbestos roofing, do not make a satisfactory product.

Asbestos fibre is peculiar to itself in that unlike wool or other fibres used in roofing felts, it is non-tubular, therefore, it does not take the oil into the fibre tubes as in the case of organic fibres, but each fibre is individually coated on the outside and the mass so amalgamated that with the natural asphalt and non-volatile oil, the water-proofing of the roofing fabric is prolonged indefinitely and is not affected by the loss of the water-proofing element by capillary attraction or the oxidizing effects of the sun and air, which is the case in the ordinary felt roofings.

Asbestos Lumber.—Certain grades of shorter fibres of asbestos have, of recent years, been used very extensively in combination with Portland or hydraulic cements in the manufacture of fire-proof lumber and roofing. The fire-proof lumber in the shape of sheets in size approximately 42″ x 96″, in all thicknesses from one-eighth of an inch to one inch and the asbestos roofing in the form of shingles of various shapes and sizes approximating the thickness of slate.

The most approved type of manufacturing these products, and in fact, the only manner in which the most durable and mechanically correct product of this nature can be made, is by mixing the asbestos fibre and the hydraulic cement dry, pressing in form presses under enormous hydraulic pressure, saturating with water, in order to give the proper set to the hydraulic cement and re-pressing and trimming in order to make an article of commercial value.

The larger sheets of asbestos lumber have been largely used for large area roof coverings on steel and wooden roof structures, siding, etc., proofing, partition work, and while this material has not as yet come into general use, the enormous economic waste through fire loss and the demand by the public for greater fire prevention, coupled with the increased cost of ordinary lumber, will unquestionably make it a staple fire-proofing material, where the structural requirements permit.

Asbestos Shingles.—The great fire hazard found in wooden shingles, and the fact of the scarcity and increased cost of lumber from which these shingles are produced, and the weight and brittleness and other points of unreliability of slate, has brought the asbestos shingle into marked prominence immediately upon its being offered to the public. The asbestos shingle is light in weight, absolutely fire-proof and indestructible.

Neither of the materials used in their makeup, asbestos fibre and Portland cement, are in any way affected by fire, temperature or exposure to the elements; and the asbestos shingles will last as long as the structure upon which they are used. It is reasonable to assume that their life is indefinite, and the success with which the sale of these shingles has met in the time they have been on the market, warrants us in assuming that in but very few years to come, they will be the standard roof covering for all types of buildings, where slate and wooden shingles have heretofore been used.

It might be interesting to state that asbestos shingles differ from slate in that they will withstand a very high heat such as may affect them from neighboring fires and while hot, may be wet down with water without in any way injuring them. Slate, of course, under these conditions, would crack and wooden shingles would be readily consumed.

Furnace Linings.—Asbestos fibres are used as bond with certain high temperature resisting clays and certain forms of graphitic carbon, for the purpose of forming linings for stoves, ranges, furnaces, brass melting furnaces, setting up of fire brick, etc., and whereas fire clay even of the very best quality under high temperatures, will fuse and become brittle and lose its binding qualities, these asbestos fire-resisting cements, according to their various grades and ingredients, will withstand temperatures up to 3,000 degrees and somewhat over, without in any way being affected, thus prolonging the life of the apparatus with which they are lined or the brick construction where they are used as bond.

These cements are furnished in dry form for mixing with water or in plastic form all ready for use.

Certain forms of the fire-resisting cements above described are capable of being moulded under hydraulic pressure for various conditions where high temperatures are to be met, such as carrying-in paddles, bottle rests and many other articles known to the glass manufacturing and electrical industries.

Asbestos in this form is especially adapted for use in glass manufacturing in place of iron, because the absence of any great amount of expansion and contraction, as compared with the great amount of the same in iron, does away with the tendency found in the use of iron causing considerable breakage in handling hot glass articles.

These pieces are also used in the jewelry trade for melting and soldering purposes.

Asbestos fibres of different lengths, both long and short, are used in moulding pieces of innumerable designs and sizes, where a material with considerable dielectric strength, combined with fire-resisting qualities is required. The fibres are mixed with various insulating compounds, pressed in moulds into various forms to be used in electrical machinery or in electrical apparatus, such as controller linings, arc deflectors, etc. In this field alone, asbestos has gone a great ways to assist in developing electrical apparatus to its modern high state of perfection.

Ebonized Asbestos Wood.—This consists of boards made from asbestos fibre and magnesite cement in place of the hydraulic cement, manufactured and prepared for market in exactly the same way as the regular asbestos lumber. Ebonized asbestos wood is impregnated with a bituminous compound which renders it absolutely impervious to moisture and gives it an unusually high dielectric strength.

It is especially used in place of slate and marble for switch boards and panel boards and it has practically 50 per cent greater dielectric strength than either slate or marble, and unlike these two materials, it is not brittle and easily broken, but has great mechanical strength to withstand the shocks of transportation and service.

Some of the largest power plants in the states have equipped their switchboards throughout with ebonized asbestos wood, with the most satisfactory results in point of saving in operation, the original cost being but slightly more than slate or marble.

Asbestos Tape.—Asbestos paper in the form of ribbon or tape one one-hundreths of an inch thick, together with asbestos yarns, is used for the covering of electric wires and cables in connection with insulating compounds, affording a high electrical resistance with very considerable fire-proof qualities.

Thin woven asbestos tape .010 and .015 thick, has in the last two or three years been produced for winding of armatures, etc., in various types of electrical apparatus, as well as the covering of wires, cables, leads, etc.

One very important development of asbestos is in the fire-proof covering of individual cables running from a large power plant, where a blow-out in one cable would result in the destruction of the insulation of the cables next adjoining. Here asbestos roll fire felt with cloth backing, one-eighth of an inch or one-quarter of an inch thick in strips three inches wide, is wound spirally around each cable, treated with a hardening or water-proofing compound superficially, the purpose being to prevent the spread of flames from the blow-out of the cable to the destruction of the insulation on nearby cables.

Asbestos Plaster.—The very lowest grade of asbestos fibre, especially those which still contain a large percentage of serpentine rock, has found a very large use in the manufacture of plaster for interior as well as exterior purposes. There has been an unusual development of the stucco house both on terra-cotta blocks and wire lath over wood boards in the states, and while there has long been a desire for this particularly attractive style of construction, it was never formerly popular, because the only available materials, sand and Portland cement, had a tendency to crack and discolor.

Asbestos stucco, however, has overcome these objections and thousands of tons are now used throughout the country. In fact, it has made possible a durable stucco house of pleasing appearance. It is mixed with Portland cement water-proofing material, in proper quantities, and applied in exactly the same manner as any Portland cement mortar.

It has also entered very largely into use for the interior plastering of the largest public buildings, and is now, because of its fire-proof qualities, being generally recognized throughout the large cities as a most desirable addition to fire-proof building materials.

REINFORCED CONCRETE

Concrete without reinforcement is a composite material, or artificial stone having the structural virtue of resisting to a high degree compression stresses, thus being generally used for foundation purposes. Concrete has no value in resisting tension or pulling stresses unless it is reinforced or armoured with steel introduced in such a manner as to bring the compressive stresses upon the concrete itelf and the tensile stresses upon the imbedded steel.

Properly designed and executed there is no form of construction which admits of greater versatility of application. There is hardly any class of structure to which reinforced concrete cannot be applied. At the present time reinforced concrete cannot be treated by the general use of fixed formulas as standardized in the use of other structural materials such as wood and steel. Although the various concerns have formula covering the application of their patented reinforcing materials, there still remain problems which can only be properly solved by specialists, and works of any magnitude should be under the direct supervision of one who has had experience in this field of engineering. The requirements for the successful designing and executing of reinforced concrete work are numerous; in fact this field of engineering work is again subdivided into specialties involving different patented systems.

The reinforced concrete specialist or engineer should be thoroughly conversant with the analysis of all stresses entering into the problem in order to properly design the various constructive members. He should be familiar with the various forms of patented systems and their limitations in order to make the best selection for the purpose intended. It is also necessary to determine the proper selection of the aggregate (cement, sand and stone) available at or near the site of the proposed construction work as well as making the proper laboratory tests of the cement, sand and stone if there is any question relative to the merits of the same for the work intended.

The success or failure in reinforced concrete construction is largely a matter of experience, organization and honesty. Care and skill must be present in every step in the design and execution of reinforced concrete work. The experimental stage of reinforced concrete construction is over as the strains and stresses can be accurately figured and the most intricate designs are readily executed; but there still exists certain conditions in some forms and locations of structural members where reinforced concrete cannot economically replace these forms.

Limitations of Reinforced Concrete.—In the application of reinforced concrete the design of structures must be positively determined, together with the arrangement of stairways, elevators, pipe shafts, etc., as well as the location of machinery. Changes are seldom practical when the work is under way. It is expensive and difficult to cut out floor openings for pipes, etc. The application of reinforced concrete for light floor loads such as 100 to 125 pounds per square foot involves relatively high costs over plank and timber or steel construction. Reinforced concrete is heavier than steel work for supporting the same loads, hence a high percentage of dead to live loads.

Desirable Features.—Fire resisting qualities, low insurance rates, freedom from vibration and repairs, durability, increasing with age, solidity and lack of joints, sanitary value, good foundations for delicate machinery, or where such machinery must be kept in alignment; water tight floors readily arranged, large window areas available, owing to economical column and pier construction; freedom from decay by infection of moisture, low competitive costs with timber—when used for heavy floor loads as above 200 pounds per square foot,—conducive to cleanliness, no harbors for vermin, versatility of application, suitability for heavy floor loads, powerful resistance to disintegration by sudden cooling, and ability to sustain shock or impact. As Portland cement concrete and steel are acted upon by temperature to precisely a similar degree, expanding and contracting in a similar manner, the assembling of these materials in proper combination enables reinforced concrete to rank as one of the most important of structural materials.

Design.—The working compressive strength of concrete is about 500 pounds per square inch; its working tensile strength is about 50 pounds, which is generally disregarded in design. The ratio of modulus of elasticity of concrete to that of steel is 1 to 15 or for the same amount of compression a given area of steel will take 15 times as much load as the same area of concrete. Steel will take 300 times as much tension as concrete.

The safe combination of concrete and steel requires a thorough knowledge of all the principles of mechanics with the theories involved. As the action of the various stresses even in a simple beam are complex, it is necessary to determine just how much of the load the concrete or steel is to carry as well as the proper distribution of the steel to take up every tensile strain which may occur in any part of the beam. In a beam supported at both ends the tension or pull is in the bottom and the reinforcing steel must be as near the bottom as is consistent with rust and fire protection. If such a beam is built into a column or into another beam, a load upon it will produce a tensile strain at the top of the beam over its supports which will tend to crack it there, and in addition there are secondary stresses in the interior of the beam; partly shear or tendency to slide and partly tension or pulling. All such stresses must be taken up by the reinforcing metal which must be properly calculated and placed in the correct position.

Materials

Cement.—In reinforced concrete, Portland cement is the only safe material to use, and only such cement should be approved as meets the tests specified by the American Society for Testing Materials and the rules adopted by the American Society of Civil Engineers. Portland cement is much stronger than natural cement, more reliable and hardens more rapidly.

The average chemical analysis of Portland cement is as follows: Carbonate of lime 62%, silica 22%, alumina 8%, oxide of iron 3%, magnesia 2%, sulphuric acid 1¼%. It is advisable to select only such brands of cement as bear a good reputation, and as a further safeguard, samples should be taken from every fortieth sack in bulk shipments.

Sand.—The strongest mortar is made with sand passing a No. 20 sieve and resting on a No. 30 sieve. Sand of proper grade and quality is just as necessary as the proper cement in order to obtain the best results. It is advisable to test the various sands to find which one has the greatest compactness.

Silicians and calcareous varieties of sand are the best. Bank pit sand is preferable to shore sand as it has sharper edges which make a better bond with the cement than the smooth round grains of shore sand. A mixture of varying size grains of sand yields a stronger mortar than sand of uniform grain, whether coarse or fine. Mortar with fine sand requires twice the quantity of cement to obtain a given strength as when coarse sand is used. Coarse sand even to the finer gravels are used by the best concrete engineers. Argillaceous sand should not be used; the presence of organic matter and other impurities is detrimental to any sand for structural purposes.

The ideal or dense mixture is where all the spaces between the stone or gravel are filled with sand and all the spaces between the different particles of sand are filled with cement.

The amount of cement and sand to make a unit volume of mortar should be determined. Mortar dropped from a trowel should leave it perfectly clear. It should be readily moulded into a ball and if dropped 20 inches should retain its rounded shape without cracking.

Gravel.—Gravel is equal to trap rock for strength, but as it spalls off under intense heat should be preferably used in foundations where it would not be affected by fire. The gravel should be absolutely clean and well screened.

Stone.—Stone should pass a ¾ inch ring for all work above foundations and not over a 1½ inch ring for foundation work. Only such hard durable rock as trap, limestone, or granite should be used. While sandstone makes a good concrete, the strength is variable and it should only be used in connection with the lowest strength shown by testing. The stone should be free of dust and deleterious matter.

Water.—The water used in mixing concrete should be free from acids or strong alkalies.

Steel.—When the elastic limit of the reinforcing metal is passed, providing all other stresses are proportionately taken care of, the concrete beam fails;—for conservative practice a tensile strength of 60,000 pounds; an elastic limit of from 30,000 to 40,000 pounds; an elongation of 2% in 8 inches, and bending cold 180 degrees without fracture, are considered fair requirements of steel.

The various patented bars have elastic limits from 30,000 to 60,000 pounds, and ultimate strength from 60,000 to 100,000 pounds.

Ordinary working stresses range from 15,000 to 22,000 pounds per square inch in tension, and from 10,000 to 12,000 pounds for shear.

The cross bands, distribution of stresses and of the reinforcing metal itself varies in accordance with the type of system used. The best engineers figure plain round rods should not be used when the fibre stress exceeds 10,000 pounds per square inch, as there is danger from the adhesion being destroyed by the rods slipping. Square bars should not be used where the fibre stress is over 12,000 pounds.

Medium steel having a high elastic limit is favored by many engineers, as the elastic limit of the steel governs the steel stresses used in the design of reinforced concrete.

Medium steel deformed cold increases the elastic limit and ultimate strength. At the same time the initial qualities of the steel are preserved without the steel becoming brittle.

While high carbon steel has a much higher yield point than mild steel, brittleness should be considered, and only well melted and rolled steel free from impurities, such as phosphorus, should be used. If a good grade of high carbon steel, where the carbon ranges from .45 to .60%, is used in reinforced concrete work the danger from shock is remote, but to insure such safety rigid specifications should be followed.

Proportions of Materials.—In building construction, the general rule for proportioning the materials is as follows: 1 part cement, 2 parts sand, 4 parts broken stone or gravel, or what is known as a 1:2:4 mixture.

Concrete for reinforced footings is often made of a mixture of 1 part cement, 2½ part sand to 5 parts broken stone or gravel. Concrete for foundations which do not require reinforcement and sustain direct compression is often made of 1 part cement, 3 parts sand to 6 parts broken stone or gravel.

The richer the mixture, the greater the compressive strength. The greater the impermeability, the greater the change in volume.

ULTIMATE COMPRESSIVE STRENGTH AND FIBRE STRESSES OF DIFFERENT CONCRETES

Material	Mixture	Ultimate Strength	Fibre Stress	Factor of Safety
Trap rock Granite Gravel Limestone	1-2-4	2,500 lbs.-3,000 lbs.	625 lbs.-750 lbs.	3
	1-3-5	1,800 lbs.-2,000 lbs.	450 lbs.-500 lbs.	4
Sandstone	1-2-4	1,400 lbs.-1,800 lbs.	280 lbs.-360 lbs.	5
	1-3-5	1,100 lbs.-1,500 lbs.	220 lbs.-300 lbs.	5

See also abstract from the National Board Building Code, given hereinafter on page 327.

NATIONAL BOARD BUILDING CODE

The following definitions and specifications are taken from the Model Building Code prepared by the National Board of Fire Underwriters; the same section numbers have been retained as in the code and where reference is made to a section, it will be found herein, either under this general heading, pages 293 to 349, or under the chapter on Fire Protection for People in Buildings, pages 465 and 483. All illustrations and diagrams are reproduced from the original cuts by permission of the National Board.

Definitions

Areaway.—An open sub-surface space adjacent to a building for lighting or ventilating cellars or basements.

Area of a Building.—The area of the horizontal cross-section at the ground level measured to the center of party walls or fire walls, and to the outside of other walls.

Basement.—A story partly but not more than one-half below the level of the curb.

Bearing Wall.—A wall which supports any load other than its own weight.

Bulkhead or Pent House.—A structure erected on the roof of a building for the purpose of enclosing stairways to the roof, elevator machinery, water tanks, ventilating apparatus, exhaust chambers or other building equipment machinery and for janitor's quarters. When used only for the above mentioned purposes, such structures need not be considered in determining the height of the building.

Cellar.—A story whose height is more than one-half below the level of the curb. It shall not be counted as a story in determining the height of a building.

Cement Plaster.—A plaster composed of one part Portland cement, not more than three parts sand, and not more than 10 per cent by volume of hydrated lime, with hair or other binder when necessary.

Cement-tempered Plaster.—A lime or gypsum plaster tempered with not less than 20 per cent of Portland cement.

Curtain Wall.—Any exterior non-bearing wall between columns or piers, which is not supported by beams or girders at each story.

Dead Load.—The weight of the walls, framing, floors, roofs, tanks with their contents, and all permanent construction.

Division Wall.—Any interior wall in a building.

Dwelling.—A residence building, designed for, or used as, the home or residence of not more than two separate and distinct families.

Enclosure Wall.—See Panel Wall.

Exterior Wall.—Any outside wall, or vertical enclosure of a building, other than a party wall.

Factory.—A building or portion thereof, designed or used to manufacture or assemble goods, wares, or merchandise, the work being performed wholly, or principally by machinery.

FIBRE PLASTER BOARD.—A board consisting of an intimate mixture of gypsum plaster composition and a fibrous binding material.

FIRE DOOR.—A door, frame, and sill which will successfully resist a fire for one hour in accordance with test specifications, and has been approved upon such test.

FIRE EXIT PARTITION.—A sub-dividing partition built for the purpose of protecting life by providing an area of refuge.

FIREPROOF.—Refers to materials or construction not combustible in the temperatures of ordinary fires, and which will withstand such fires without serious impairment of their usefulness for at least one hour.

NOTE.—It is recognized that the term "fireproof" is misleading and should be abandoned for the more correct term "fire-resistive;" but until the latter term has been authoritatively defined in a manner expressive of its elastic interpretation, it seems advisable to continue the use of the more common though objectionable word.

FIRE SHUTTER.—A shutter which will successfully resist a fire for one hour in accordance with test specifications, and has been approved upon such test.

FIRE WALL.—A wall built for the purpose of restricting the area subject to the spread of fire.

FIRE WINDOW.—A window frame, sash, and glazing which will successfully resist a fire for one hour in accordance with test specifications, and has been approved upon such test. No single pane in a fire window shall exceed 720 square inches.

FOUNDATION WALL.—Any wall or pier built below the curb level or nearest tier of beams to that level.

GYPSUM BLOCK.—The term "gypsum block" shall include tile or blocks composed of gypsum and not to exceed 5 per cent by weight of combustible fibre binding material; or a mixture of crushed cinders and gypsum, commonly called "cinder-plaster blocks."

HEIGHT OF A BUILDING.—The vertical distance from the curb level to the top of the highest point of the roof beams in the case of flat roofs, or to the average height of the gable in the case of roofs having a pitch of more than 20 degrees with a horizontal plane. When a building faces two or more streets having different grades, the measurement shall be taken at the middle of a facade on the street having the greatest grade. When a building does not adjoin the street, the measurement shall be taken from the average level of the ground adjoining such building. In measuring the height of a wall, the height of the parapet above the top of the roof beams shall not be included.

HOTEL.—Any building or portion thereof, designed or used for supplying food or shelter to residents or guests, and containing more than fifteen sleeping rooms above the first story.

INCOMBUSTIBLE.—Materials or construction which will not ignite and burn when subjected to fire.

LENGTH OF A BUILDING.—Its greatest horizontal dimension.

LIVE LOAD.—All loads other than dead loads. All partitions which are subject to removal or rearrangement shall be considered as live load.

NON-BEARING WALL.—One which supports no load other than its own weight.

OFFICE BUILDING.—One used for professional or clerical purposes, but not for manufacturing, storage, or sale of goods except by sample; also excepting the first story which may be used for commercial purposes. No part of such building shall be used for living purposes except by the janitor's family.

OUTHOUSES.—All structures not exceeding 8 feet in height, nor more than 150 square feet in area, exclusive of sheds.

PANEL OR ENCLOSURE WALL.—An exterior non-bearing wall in a skeleton structure built between columns or piers and supported at each story.

PARAPET WALL.—That portion of any wall which extends above the roof line and bears no load except as it may serve to support a tank.

PARTY WALL.—A wall used or adapted for joint service between two buildings.

PUBLIC HALLWAY.—A hall, corridor or passageway used in common by the occupants of a building and serving as a means of communication for the public between an entrance to any story of a building, and the various rooms, apartments or spaces in that story.

RETAINING WALL.—One constructed to support a body of earth or to resist lateral thrust.

SHED.—A roofed structure, open on one or more sides, which does not exceed 15 feet in height nor more than 500 square feet in area.

SKELETON CONSTRUCTION.—A form of building construction wherein all external and internal loads and stresses are transmitted to the foundations by a rigidly connected framework of metal or reinforced concrete. The enclosing walls are supported by girders at each story.

SKYLIGHT.—Any cover or enclosure placed above roof openings for the admission of light.

STORY.—That part of any building comprised between any floor and the floor or roof next above. In case any floor or the combined area of floors at any one level extends over less than 20 per cent of the horizontal area included within the outside walls at that level, the same shall not be considered as a floor for the purpose of determining story heights.

STRUCTURE.—Includes the terms building, appurtenance, wall, platform, staging, or flooring used for standing or seating purposes; a shed, fence, sign, or billboard on public or private property, or on, above or below a public highway.

WAREHOUSE.—A building or portion thereof, designed or used for the storage of goods, wares, and merchandise.

WIDTH OF A BUILDING.—The horizontal dimension next in value to the length.

WIRED GLASS.—Glass not less than ¼ inch thick enclosing a layer of wire fabric reinforcement having a mesh not larger than ⅞ inch, and the size of wire not smaller than No. 24 B. and S. gauge.

WORKSHOP.—A building or room in which articles of merchandise are manufactured or repaired wholly or principally by hand.

Classification of Buildings

FRAME CONSTRUCTION.—A building having the exterior walls or portions thereof of wood; also a building with wooden framework veneered with brick, stone, terra cotta, or concrete; or covered with plaster, stucco, or sheet metal, shall be classed as a frame building.

NON-FIREPROOF CONSTRUCTION.—The term "Non-Fireproof Construction" shall apply to all buildings or structures having exterior masonry walls with floors and other interior construction wholly or in part of wood.

(a) Ordinary Construction.—A building having masonry walls, with floors and partitions of wooden joist and stud construction. The supporting posts and girders may be of wood, or of metal protected.

(b) Mill Construction.—(Sometimes called "Slow-burning Construction.") A building having masonry walls, and heavy timber interior construction.

FIREPROOF CONSTRUCTION.—Buildings of masonry, steel, or reinforced concrete construction in accordance with Sections 110 to 173, shall be considered fireproof.

Class A.—Armories, Asylums, Bath Houses (with sleeping accommodations other than those required for janitor), City Halls, Colleges, Court Houses, Detention Buildings, Police Stations, Hospitals, Libraries, Museums, Nurseries, Railway Passenger Stations, Schools, and Theatres.

Buildings of this class shall be of fireproof construction, except that schools in which no pupils are accommodated above the second story may be of non-fireproof construction.

Where armories, railway passenger stations, museums and similar buildings have large arched exposed roof construction, the fireproofing of the structural members of these roofs may be omitted if, in the opinion of the Superintendent, the construction of the remainder of the building would reasonably warrant such omission.

Class B.—Amusement Halls, Churches, Exhibition Buildings, Lodge Rooms, and Public Halls.

All buildings of this class shall have the floor over cellar or basement which is nearest to grade level of fireproof construction.

Buildings of this class over three stories, or 40 feet high, shall be of fireproof construction throughout, except that church spires need not be fireproof until they exceed 75 feet in height.

Every permanent structure intended for the seating or accommodation of the public, commonly known as grandstands, erected within the fire limits, shall be of fireproof construction, except that the seats may be of wood, and the structural steel work may be unprotected. When portions of such structures are enclosed, the enclosing construction shall be fireproof.

Class C.—Bachelor Apartments, Club Houses, and Studios with more than 15 sleeping rooms, Dormitories, Hotels and Lodging Houses.

Buildings of this class when permitted of frame construction shall not exceed two stories or 30 feet in height.

All buildings of this class three stories in height shall have the floor over cellar or basement which is nearest to grade level of fireproof construction.

Buildings of this class over three stories or 40 feet high, shall be of fireproof construction throughout.

Class D.—Dwellings, Tenement Houses, and all other Residence Buildings not specified in Class C.

Buildings of this class over three stories, or 40 feet high, shall have the floor over cellar or basement which is nearest to grade level of fireproof construction.

Buildings of this class over four stories, or 55 feet high, shall be of fireproof construction throughout.

When the lower stories or portions thereof in non-fireproof buildings of Classes C and D are occupied for business purposes, the construction shall be made in accordance with the requirements of Section 98.

Frame buildings, Sec. 187-192.

Class E.—Factories, Lofts, Office Buildings, Printing Houses, Restaurants, Stables, Stores, Warehouses, and Workshops.

Buildings of this class of ordinary construction over two stories, or 30 feet high, shall have the floor over the lowest story of fireproof construction; buildings of this class over four stories, or 55 feet high, shall be of fireproof construction throughout, or of mill construction. Mill construction buildings shall not exceed 65 feet in height.

Class F.—Car Barns, Foundries, Light and Power Plants, Railroad Freight Stations, Ice Houses; also Special Industry Buildings, constructed and occupied exclusively for a special purpose or industry and not otherwise classified, such as Coffee Roasters, Dry Cleaning Establishments, Grain Elevators, Ice-Making Plants, Laboratories, Malt Houses, Oil Houses, Oil Refineries, Refrigerating Plants, Rendering Plants, Soap Factories, Sugar Refineries, Smoke Houses, Slaughter Houses, Wharf Buildings, also Garages accommodating more than three cars, or in which cars are stored on more than one floor.

Buildings of this class, such as garages (as herein defined), oil houses, oil refineries, rendering plants, smoke houses, varnish works, etc., and buildings or portions of buildings which are used for the storage or handling of large quantities of combustible packing or refuse material, shall be only of fireproof construction. All other buildings of Class F shall be of fireproof or mill construction if within the fire limits or if they exceed 55 feet in height.

Height of mill construction, Sec. 37.

Buildings of Class F, whether of fireproof construction and within the fire limits, or of non-fireproof construction and outside the fire limits, shall only be erected in such isolated localities and under such conditions as are approved by the Superintendent of Building Construction.

Walls

SECTION 27. PANEL OR ENCLOSURE WALLS FOR SKELETON CONSTRUCTION.—In skeleton construction the panel walls shall be supported by girders at each floor level, and if of brick, shall be not less than 12 inches thick, laid in cement mortar. When the vertical distance between supporting girders exceeds 15 feet the thickness of the wall shall be increased 4 inches for each 15 feet or fraction thereof that the said vertical distance exceeds 15 feet. Such walls shall be of brick, stone, or gravel concrete, or hard burned terra cotta.

Reinforced concrete walls, Sec. 147.

Terra cotta in skeleton construction, Sec. 31, par. 7.

SECTION 28. CURTAIN WALLS.—Curtain walls over three stories or 50 feet in height shall be laid in cement mortar, and shall be not less than 12 inches thick for the uppermost 50 feet thereof, or nearest tier of beams to that height, and increased 4 inches for every additional section of three stories or 45 feet, or nearest tier of beams to that height. When such walls are used, the foundation of the buildings shall be so designed that the load from the columns and the load of the walls are carried together. Curtain walls shall be anchored to the steel framing at each floor level, the anchors being spaced not further apart than 6 feet horizontally. See 4 and 5, Figure 22.

SECTION 29. FIRE WALLS.—1. Fire walls shall be built of brick laid in Portland cement, mortar, or of reinforced concrete. In fireproof buildings, brick fire walls supported by girders at each story, may be 12 inches thick throughout. In none-fireproof buildings, brick fire walls which do not serve as bearing walls shall be not less than 16 inches thick in the upper four stories or upper 50 feet, increasing 4 inches in thickness for each two stories or fraction thereof below. See Fig. 21. No such two-story increment shall exceed 30 feet in height. In frame buildings used for manufacturing or commercial purposes, and not exceeding two stories or 30 feet in height, non-bearing fire walls shall be not less than 12 inches thick.

2. Every opening in a fire wall or a party wall, shall be protected on each side of the wall by an approved automatic fire door. No opening in any such wall shall exceed 80 square feet in area, except that by written per-

DIAGRAMS SHOWING RELATION OF ALLOWABLE WALL HEIGHTS TO MINIMUM REQUIRED THICKNESS

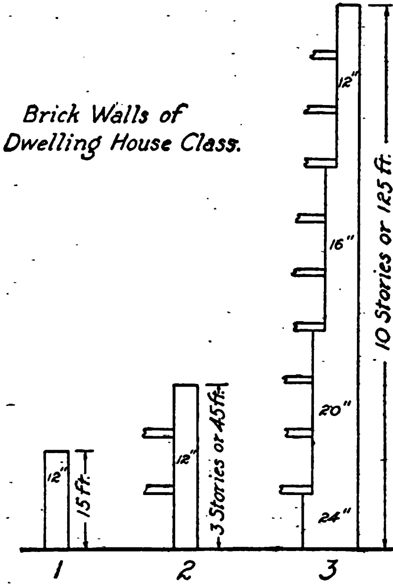

FIG. 20

1. Maximum height of a single story, 12 inch wall.
2. Maximum height of a 12 inch bearing wall.
3. Minimum thickness of a ten-story bearing wall.

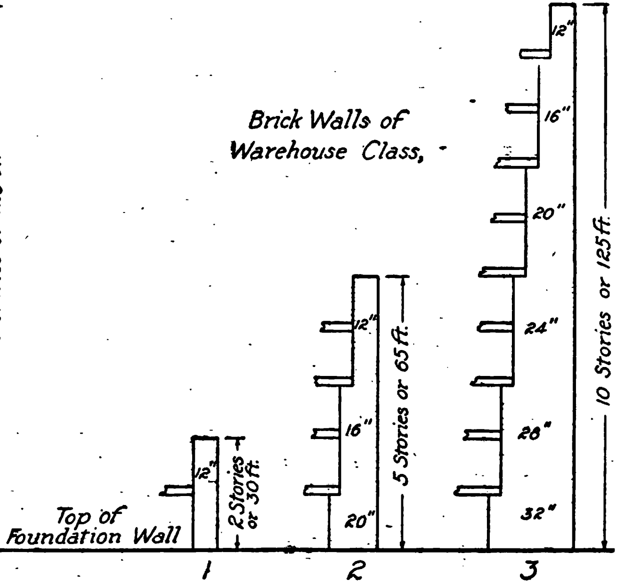

FIG. 21

1. Maximum height of a 12 inch bearing wall.
2. Minimum thickness of a bearing wall not exceeding five stories in height.
3. Minimum thickness of a ten-story bearing wall.

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mission of the Superintendent, a larger opening may be had upon the ground floor only; but special precautions shall be taken, to protect such opening, and in no case shall the total width of openings in any one story, other than the first story, exceed 25 per cent in linear length of the wall. Fire and party walls shall be continuous from foundation to 3 feet above roof level and be coped, except that such walls in fireproof buildings need not extend above the top of the roof beams.

3. When three or more buildings used for stores, factories or warehouses; communicate by openings through separating fire walls, the openings shall be protected by double fire doors, and each building shall also be provided with a system of approved automatic sprinklers.

NOTE.—The great value of solid walls in restricting the spread of fire is so well known, argument should be unnecessary to insure their use wherever suitable. A fireproof factory or warehouse with properly restricted areas between fire walls, equipped with automatic sprinklers, and having proper protection to vertical openings and windows, would be practically impossible to burn. The truth of this statement has been demonstrated many times. The folly of building otherwise is a self-evident verity.

Fire walls are as useful in protecting school buildings, hospitals, hotels, state and county buildings, large residence buildings, and in fact any building having considerable area, as they are in other types of buildings. In such public buildings where numerous people are housed, many of whom may be invalids or infirm, the life saving features of properly constructed fire exits through fire walls, cannot be overestimated. The additional expense of such cut-offs is slight, and neither the architectural effects, nor the utility of the building, need be affected by their introduction. Necessary openings in such walls when not large, can be efficiently protected by fire doors as artistic in finish as ordinary doors. It is no longer necessary to be restricted to the unsightly tin clad fire door for such use.

4. If an opening in a fire wall is made to serve as an emergency or horizontal exit, and is included in the calculations for exits, it shall not exceed 48 square feet in area, and a self-closing fire door shall be substituted for one of the automatic fire doors. The automatic door shall be controlled by an approved automatic door release on each side of the wall.

NOTE.—A self-closing fire door is one which is normally kept in a closed position by some mechanical device.

An automatic fire door is one which is arranged to close when released by the action of heat.

Self-closing fire doors used on exit openings in fire walls, should have a standard of quality at least equal that required for stairway doors. Such doors are intended to prevent the passage of smoke through the opening, which might under certain conditions, render an adjoining floor area untenable before the heat would be sufficient to close the automatic door. For this reason the self-closing door should never be allowed to be held open mechanically for more than a few minutes at a time when strictly necessary for transporting goods through the doorway or for similar service. Under no circumstances should it be held open by a mechanical device other than one which contains a fusible link as an integral part. Such device shall be attached at the top of the door.

If other openings in a fire wall communicate directly with an area of refuge included in the calculations for exits and protected by a self-closing fire door as above described, the automatic fire doors protecting such openings should be kept closed at all times except for short periods when strictly necessary for the transportation of goods.

Horizontal exits, as emergency exits, Sec. 46, par. 2, (c).

SECTION 30. PARAPET WALLS.—All exterior or party walls over 20 feet high, except where such walls are finished as cornices, gutters, or crown mouldings, excepting also the walls of detached dwellings with peaked or hipped roofs, shall be furnished with parapets. Parapet walls shall be the full thickness of the top story walls and shall project at least 3 feet above

DIAGRAMS SHOWING RELATION OF ALLOWABLE WALL HEIGHTS TO MINIMUM REQUIRED THICKNESS

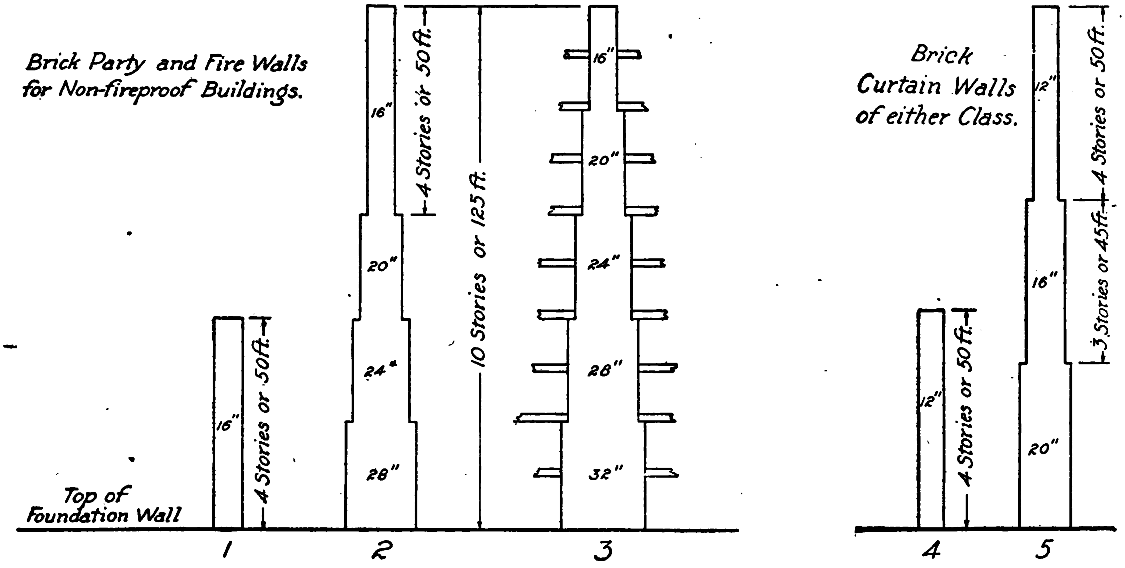

FIG. 22

1. Minimum height of a 16 inch party or fire wall.
2. Minimum thickness of a ten-story non-bearing party or fire wall.
3. Minimum thickness of a ten-story bearing party or fire wall.
4. Maximum height of a 12 inch curtain wall.
5. Minimum thickness of a ten-story curtain wall.

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the roof at all points, except that on dwellings the parapets may be reduced to 2 feet. All parapet walls shall be coped with approved durable material.

Parapets on fire walls, Sec. 29, par. 2.

SECTION 31. HOLLOW BUILDING BLOCK WALLS.—1. Hollow building blocks of hard burned terra cotta or of concrete, may be used for all walls except party and fire walls of buildings not exceeding three stories or 40 feet in height, provided that such blocks have met the test requirements of Section 58, and are not stressed beyond the safe limits therein prescribed. The minimum thickness of such walls shall be as required for brick walls.

Hollow blocks for skeleton construction, par. 7.

Building block defined, Sec. 58, par. 1.

2. Concrete blocks shall not be used in construction until they have attained an age of 28 days, nor until they have developed the required test strength. All building blocks shall be laid in Portland cement mortar.

3. If a wall be built of blocks laid with the cells horizontal, which were designed to be normally laid with the cells vertical, or if band courses of such blocks with cells horizontal be laid in a wall otherwise built of the same blocks with the cells vertical, the carrying capacity of such walls shall be calculated from the strength of the blocks tested with their cells horizontal.

Test requirements for hollow building blocks, Sec. 58.

4. Hollow terra cotta blocks in exterior walls shall be either extra hard burned or be veneered with brick, architectural terra cotta, or stone, securely bonded and set as provided in Section 21, paragraph 8, or the blocks shall be covered on the exposed surface with at least ¾ inch of Portland cement stucco; such blocks shall be well scored, grooved or roughened to retain the coating. The stucco shall not be considered as a part of the required thickness of the wall.

5. When hollow block walls, laid with cells vertical, are decreased in thickness, the blocks in the top course of the thicker wall shall be filled solidly with concrete, or the exposed openings in such top course may be covered with slabs of hard burned terra cotta or concrete at least 1 inch in thickness. Terra cotta, concrete or metal slabs or templates of approved size and thickness shall be placed under all floor beams and girders as bearing plates in order that the allowable working stresses shall not be exceeded.

Hollow blocks filled with concrete, Sec. 58, par. 8.

6. Building blocks shall be so laid that the shells and webs shall be superposed upon the shells or webs of the adjacent block or blocks below.

7. Hollow blocks when used to form lintels, which are not keyed arches, shall be reinforced with steel rods, and be filled solidly with concrete. Such lintels shall be designed in accordance with the unit stresses and other requirements for reinforced concrete as required in Section 117, etc.

8. Except for party or fire walls, hard burned terra cotta blocks may be used for walls of skeleton construction having a height not exceeding four stories or 55 feet. The thickness shall be the same as required for brick walls. Terra cotta blocks faced with brick bonded in the manner specified in the last half of paragraph 8, Section 21, may be used for walls of skeleton construction to a height of 10 stories or 125 feet.

NOTE.—It is recommended that hollow building blocks having shells or webs one inch or less in thickness, which are laid with cells vertical in walls which have unusual length or height between supports, or which are liable to be subjected to stresses which would make them unstable, shall be reinforced by interior metal supports, or that a layer of metal fabric be embedded in each horizontal mortar joint. The fabric to be ½ inch less in width than the thickness of the wall, and to have a mesh of ⅛ to ½ inch. The fabric to be laid in the joint before the mortar is deposited and be lapped at the corners.

SECTION 33. FURRED WALLS AND HOLLOW WALLS.—1. The inside 4 inches of all walls may be built of hard burned hollow brick the dimensions of ordinary brick, properly tied and bonded into the walls. Terra cotta, concrete, or gypsum tile or blocks used as lining or furring shall not be considered as forming part of the required thickness of any wall.

2. In all hollow walls of stone, brick or concrete, the same net horizontal section shall be used as if they were solid. The parts of hollow walls shall be connected by approved ties of brick, stone, or metal, placed not over 24 inches apart horizontally and vertically. Metal ties shall have the ends bent at right angles, and be not less than 1 inch wide by ¼ inch thick, and shall extend into the wall on each side not less than 4 inches.

SECTION 34. RECESSES AND CHASES IN WALLS.—1. Recesses for stairways or elevators may be located within the required thickness of foundations or cellar walls, provided the walls are not thereby reduced to a less thickness than that required for a fourth story wall. Reinforcement shall be supplied where necessary to compensate for the diminished thickness as approved by the Superintendent.

The brick backing of recesses for alcoves and similar spaces shall be not less than 8 inches thick.

2. No pipe chases shall extend into any wall more than one-third of its required thickness. No horizontal recess or chase shall exceed 4 feet in length in any wall without express permission of the Superintendent. No recess in a wall shall be made within a distance of 6 feet from any other recess in the same wall.

Chases shall not be permitted within the required area of any pier. Chases or recesses in walls built of hollow blocks shall not be formed by cutting of blocks, or by other method which would impair the strength of the wall.

Neat fitting metal sleeves, or asbestos covering, shall be provided around pipes at each floor level, and the chases at these levels shall be filled with solid masonry for the space of one foot in height.

Heights and Areas

SECTION 37. HEIGHT OF BUILDINGS.—1. No building, or structure hereafter erected, except a church spire, shall exceed in height two and one-half times the width of the widest street upon which it fronts, nor shall it exceed the following limits:

	Height in Stories	Height in Feet
Frame buildings used for purposes other than dwellings and tenements	2	30
Frame dwellings and tenements occupied by not more than two families	2½	30
Frame dwellings occupied by not more than one family	3	35
Buildings having bearing walls of hollow terra cotta or concrete blocks	3	40
Non-fireproof buildings, ordinary construction	4	55
Non-fireproof buildings, mill construction	5	65
Fireproof buildings used for factories, stores, warehouses or workshops	7	85
Fireproof buildings used for purposes other than factories, stores, warehouses or workshops	10	125

2. If a single story building exceeds 30 feet in height the roof shall be constructed entirely of incombustible materials, and all metal framework of same shall be protected with fireproofing, except as provided in Section 11, paragraph 2.

3. A single story building not exceeding 30 feet in height may have a roof monitor not exceeding 10 feet in height.

4. No story of any building above the first story shall exceed 15 feet in height.

SECTION 38. ALLOWABLE FLOOR AREAS.—1. In every building of the character named in this section the maximum area of any floor between fire walls or exterior walls, either without or with a full equipment of automatic sprinklers, shall be as follows:

2. Non-Fireproof Construction.—(a) Tenement houses, 3,000 sq. ft.

(b) All other ordinary non-fireproof buildings, height not exceeding 55 feet.

Fronting on	Without sprinklers	With sprinklers, increase of 66⅔ per cent
One street	5,000 sq. ft.	8,333 sq. ft.
Two streets	6,000 sq. ft.	10,000 sq. ft.
Three or more streets	7,500 sq. ft.	12,500 sq. ft.

(c) Mill construction buildings, height limit 65 feet.

Fronting on	Without sprinklers	With sprinklers, increase of 100 per cent
One street	6,500 sq. ft.	13,000 sq. ft.
Two streets	8,000 sq. ft.	16,000 sq. ft.
Three or more streets	10,000 sq. ft.	20,000 sq. ft.

3. Fireproof Construction.—

(a) All buildings of Classes A, B, C, and D	No restrictions as to area.
Light and power stations	
Office buildings	

(b) All other buildings not exceeding 65 feet in height.

Fronting on	Without sprinklers	With sprinklers, increase of 66⅔ per cent
One street	10,000 sq. ft.	16,666 sq. ft.
Two streets	12,000 sq. ft.	20,000 sq. ft.
Three or more streets	15,000 sq. ft.	25,000 sq. ft.

(c) Stores, warehouses, factories, and workshops not exceeding 85 feet; and other buildings not exceeding 125 feet in height.

Fronting on	Without sprinklers	With sprinklers, increase of 50 per cent
One street	7,500 sq. ft.	11,250 sq. ft.
Two streets	10,000 sq. ft.	15,000 sq. ft.
Three or more streets	12,500 sq. ft.	18,750 sq. ft.

(d) The first floor only of any fireproof building occupied as a store may have an area of 20,000 sq. ft., and if fully protected by approved automatic sprinklers may be increased 50 per cent or have a maximum area of 30,000 sq. ft.

NOTE 1.—It is generally conceded that five stories is the maximum height to which water can be thrown effectively by a fire department from the street level, and that 50 feet is the maximum distance inside a building which can be reached by a stream through a window. These facts have been a governing consideration in the establishment of the limits of heights and areas in this Code. In addition, the width of the street upon which a building fronts and the height of the building should be considered; a building endangers adjacent property in proportion to its size and proximity to other property.

The areas given in this section are based upon an average street width of 60 feet. For less than this width, it does not appear unreasonable to require sprinklers for even smaller areas than herein given, particularly for buildings over two stories high. This could well be placed in the hands of the Chief of the Fire Department.

NOTE 2.—Attention is called to a paper entitled "Allowable Heights and Areas for Factory Buildings," distributed by the National Board of Fire Underwriters, which contains a digest of opinion of over a hundred prominent Fire Chiefs upon this subject.

Allowable Loads

SECTION 39. FLOOR LOADS.

Class of building	Live Loads Pounds per Square Foot	
	Ground and lower floors	Upper floors
Foundries, light and power plants, printing and lithographing houses, railroad freight depots	250	250
Warehouses	200	200
Car barns, garages	150	120
Fire houses	150	60
Armories, ball rooms, dance halls, exhibition buildings, factories, gymnasiums, work shops, lofts, markets, stables, stores, public halls, restaurants	120	120
Railway passenger stations	120	90
Office buildings	120	75
Court houses	100	100
Churches, libraries, museums, theatres	90	90
Schools and colleges	90	75
Asylums, bath houses, club houses, detention buildings, dormitories, hospitals, hotels, lodge rooms, lodging houses, studios	90	60
Tenement houses and dwellings	60	40

SECTION 58. BUILDING BLOCKS.—1. The term "block" as used in this section shall mean any shape of block, brick or tile which forms a hollow or cellular wall.

2. Terra cotta blocks for bearing walls shall be dense, and hard-burned or vitreous.

Portland cement only shall be used in the manufacture of concrete blocks, and the coarse aggregate shall be of suitable material graded in size, but in no case shall the maximum dimension exceed one-half the width of the minimum section of the finished block.

Tests shall be made to establish the working stresses to govern the use of blocks of each particular mark or brand. A series of ten full size blocks shall be selected from average quality stock, and shall be tested for compression.

4. Concrete blocks shall be not more than 36 days old when tested.

5. The compressive strength of building blocks shall in all cases be calculated upon the gross sectional area of the bedding faces including the cellular spaces.

All blocks submitted to test shall be bedded in plaster of paris or cement to secure an even bearing.

Two piece blocks shall be tested in pairs as set to form the two faces of the wall. The strength requirement shall be the same as for hollow blocks, and it shall be calculated upon the gross sectional wall area which would be formed by the two blocks and the space between them.

6. The average ultimate compressive strength for terra cotta blocks designed to be normally laid with the cells vertical, and which are tested with the cells in that position, shall be not less than 1,200 lbs. per square inch. The allowable working stress on such blocks shall not exceed 120 lbs. per square inch.

7. The average compressive strength of terra cotta blocks which are designed to be normally laid with the cells vertical, but are tested with the cells horizontal, shall be not less than 300 lbs. per square inch, and no block

of the set shall test less than 200 lbs. per square inch. The allowable working stress on such blocks when laid with the cells horizontal, shall not exceed 30 lbs. per square inch.

8. The average ultimate compressive strength for terra cotta blocks designed to be normally laid with the cells horizontal, and which are tested with the cells in that position, shall be not less than 800 lbs. per square inch. The allowable working stress on such blocks shall not exceed 80 lbs. per square inch.

9. The average compressive strength for concrete blocks when tested with the cells vertical, shall be not less than 800 lbs. per square inch, and 300 lbs per square inch with no block testing at less than 200 pounds per square inch if tested with the cells horizontal. The allowable working stress for such blocks shall not exceed 80 lbs. and 30 lbs. per square inch respectively.

10. Hollow building blocks may be filled solidly with Portland cement concrete or cement mortar to increase the stability and to aid in distributing the load, but the allowable working stress on such blocks shall not be greater than that permitted for unfilled blocks.

NOTE.—Tests have demonstrated that the strength of hollow terra cotta blocks is not increased by being filled with concrete, the reason being the difference in strength and elasticity of the two materials. Similar tests thus far available upon concrete blocks indicate some gain in strength by filling, but not sufficient to warrant recognition.

11. The absorption of building blocks used for bearing or panel walls, determined by taking the average test of three blocks, shall not exceed 10 per cent in 48 hours, and shall not exceed 15 per cent in any case.

12 Hollow building blocks shall not be used in fireproof buildings until they have successfully withstood a two-hour fire test as specified for partitions.

SECTION 63. WEIGHTS OF MATERIALS.—The weights of various materials shall be assumed to be as follows:

	Pounds per Cubic Foot
Brickwork—Ordinary	120
Brickwork—Pressed brick	130
Concrete—Cinder, used for floor arches or slabs, well tamped	108
Concrete—Cinder, used for filling, not tamped	60
Concrete—Stone, or gravel	144
Granite, Bluestone, and Marble	170
Limestone	160
Sandstone	145
Oak	50
Spruce and Hemlock	30
White Pine	27
Yellow Pine, Grade I	42
Yellow Pine, Grade II	35
Maple	43
Birch	45
Douglas Fir and Cypress	35

Working Stresses

SECTION 65. PERMISSIBLE WORKING STRESSES.—1. The safe carrying capacity of the various materials of construction, when not otherwise specified, shall be determined by the following working stresses in pounds per square inch of sectional area:

2. STEEL AND IRON.

COMPRESSION IN SHORT BLOCKS

	Pounds per Square Inch
Rolled steel	16,000
Cast steel	16,000
Cast iron	16,000
Steel pins, shop and power driven field rivets (bearing)	20,000
Steel field rivets (driven by hand) (bearing)	16,000
Steel field bolts (bearing)	12,000

TENSION

Rolled steel	16,000
Cast steel	16,000

Working stress on bolts in tension, Sec. 74, par. 6.
Working stress on concrete reinforcement bars, Sec. 125.

SHEAR

Steel web plates	10,000
Steel shop and power driven field rivets and pins	10,000
Steel field rivets (driven by hand)	8,000
Steel field bolts	7,000
Cast steel	9,000
Cast iron	1,500

EXTREME FIBRE STRESS

Rolled steel beams, and riveted steel beams	16,000
Rolled steel pins, rivets, and bolts	20,000
Cast iron compression side	16,000
Cast iron tension side	2,500

3. CONCRETE AND MASONRY.

COMPRESSION

	Pounds per Square Inch
Grout, Portland cement, neat	1,000
Grout, Portland cement, neat between steel in foundation not over ½ inch	1,500
Concrete, Portland cement, 1; sand, 2; stone, 4	500
Concrete, Portland cement, 1; sand, 2½; stone 5	400
Concrete. Natural cement, 1; sand 2; stone, 4	125
Concrete, Natural cement, 1; sand, 2½; stone, 5	80
Brickwork in Portland cement mortar	250
Brickwork in Natural cement mortar	208
Brickwork in lime and Portland cement mortar	208
Brickwork in lime mortar	111
Hollow terra cotta blocks, see Section 58.	
Hollow concrete blocks, see Section 58.	
Rubble stonework in Portland cement mortar	140
Rubble stonework in lime and cement mortar	100
Rubble stonework in lime mortar	70
Cut stone masonry, other than sandstone	600
Sandstone masonry	300
Granites, according to test	1,000 to 2,400
Gneiss	1,000
Limestones, according to test	700 to 2,300
Marbles, according to test	600 to 1,200
Sandstones, according to test	400 to 1,600
Slate	1,000

SHEAR

Shearing stress involving diagonal tension in Portland cement concrete, in the proportions of 1-2-4	40
Direct shear (punching shear), in Portland cement concrete, in the proportions of 1-2-4	120

Working stresses on reinforced concrete, Secs. 125, 167 and 168.

4. STRUCTURAL TIMBER.—The following stresses apply to seasoned timber to be kept under shelter in a dry location, and deflection not to increase with time. If the timber is to be used under other conditions, these stresses should be modified.

	BENDING		COMPRESSION	
	Extreme Fibre Stress	Maximum Longitudinal Shear	Perpendicular to the Grain	Parallel to the Grain, Columns with $\frac{l}{d}$ less than 10
Oak	1,400	120	400	1,000
Yellow Pine, Grade I	1,600	120	350	1,200
Yellow Pine, Grade II	1,200	85	300	900
Douglas Fir	1,500	100	300	1,100
Eastern Spruce	1,000	75	200	900
Western Hemlock	1,300	75	250	1,000
Norway Pine	1,000	75	250	800

l = unsupported length in inches
d = diameter or least side in inches

SECTION 66. WORKING STRESSES FOR COLUMNS.—1. The working stresses per square inch for all steel, cast iron, or wooden columns having flat ends shall not exceed the values given by the following formulas:

2. STEEL COLUMNS.—Working stress, $S = 16{,}000 - 70\frac{l}{r}$

Where S = allowable compression in lbs. per square inch.
l = allowable length in inches.
r = least radius of gyration in inches.

The allowable compression (S) shall not exceed 13,000 lbs. per square inch, and the ratio of slenderness $\frac{l}{r}$ shall not exceed 120, except that for bracing and for compression members resisting wind stress only, $\frac{l}{r}$ shall not exceed 150.

See Fig. 23 for comparison of formulas.

3. CAST IRON COLUMNS.—Working stress, $S = 9{,}000 - 40\frac{l}{r}$

Maximum $\frac{l}{r}$ shall not exceed 60.

4. WOODEN COLUMNS.

	For Columns with $\frac{l}{d}$ greater than 10, but not exceeding 30
Oak	$1{,}200-20\frac{l}{d}$
Yellow Pine, Grade I	$1{,}400-20\frac{l}{d}$
Yellow Pine, Grade II	$1{,}100-20\frac{l}{d}$
Douglas Fir	$1{,}300-20\frac{l}{d}$
Spruce	$1{,}100-20\frac{l}{d}$
Western Hemlock	$1{,}200-20\frac{l}{d}$
Norway Pine	$1{,}000-20\frac{l}{d}$

l = unsupported length in inches
d = diameter or least side in inches

The unsupported length of wooden columns and compression members shall not exceed 30 times the diameter or least side, nor shall the unit stresses exceed those given in the table in Section 65 for $\frac{l}{d}$ less than 10.

Wooden columns with $\frac{l}{d}$ less than 10, Sec. 65, par. 4.

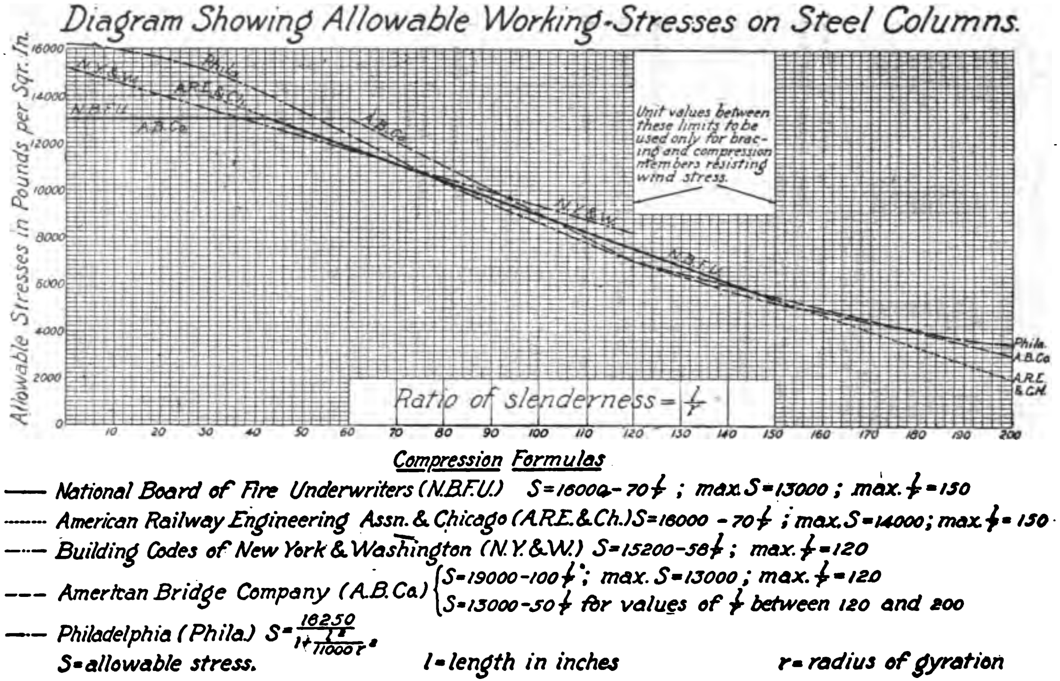

FIG. 23

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SECTION 75. PROTECTION OF STRUCTURAL METAL AGAINST CORROSION.—1. All metal structural work shall be cleaned of all scale, dirt, and rust, and be given one coat of paint at the shop completely covering all exposed surfaces. After erection all such work shall be painted at least one additional coat of a shade different from the first coat. The first coat of paint shall be made of pigments which shall be chemically inert after application, and shall be mixed with linseed or other drying oil. The amount of volatile matter shall be sufficient for easy spreading, and shall not injure the film of the paint. The paint must dry sufficiently hard within 24 hours so that it will not rub off or abrade easily. When the steel reaches the job all abraded or injured portions must be thoroughly recoated with the same material as the shop coat before the second coat is applied. The second coat of paint shall be such as will not act as a solvent of the first coat, and shall be mixed with a pigment which shall be inert after application, and the vehicle shall be one that will not saponify under the action of cement mortar.

2. Surfaces of riveted work which come in contact with each other, shall be painted with two coats of paint before assembling.

3. All iron or steel used in damp locations or under water shall be embedded in Portland cement concrete. No paint shall be applied to the steel surfaces which are to be encased in concrete.

4. Any structural steel work which may be so placed as to be inaccessible for inspection after erection, shall be thorough cleaned of all rust and encased in Portland cement concrete before it is rendered inaccessible.

Protection of wall columns, Sec. 112, par. 1.

Ordinary Timber Construction

SECTION 76. WOODEN BEAMS OR JOISTS.—1. Every wooden beam in any party or fire wall shall be separated from any other beam in the wall by at least 6 inches of solid masonry. Such separation may be obtained by staggering the beams, corbeling, or by use of approved steel hangers properly anchored in the wall, and arranged to make the beams self-releasing. No wall shall be corbeled more than 2 inches for this purpose. If the beam ends are opposite each other in the wall the separation shall be not less than 8 inches. Fig. 24 indicates spacing and arrangement of beams of different thickness in a 12-inch wall which will meet the requirement of this section. The spacing could be reduced if the walls under the beams were corbeled.

NOTE.—Staggering the beams distinctly lessens the danger of transmission of fire through a wall, for the reason that the fire or highly heated air must travel through two joints at right angles to each other to pass from one beam to the other. The probability of both these joints being open is much less than in the case of one straight connecting joint.

2. No wooden floor beam or roof beam used in any building within the fire limits shall be less than 3 inches thick.

3. The thickness of wooden beams shall be not less than 3 inches in any building where the floor load is greater than 60 pounds per square foot.

4. All wooden trimmer and header beams when over 4 feet in length shall be hung in approved metal stirrups or hangers.

5. Every wooden beam, except header and tail beams, shall have bearings of at least 4 inches.

NOTE.—In designing wooden floor constructions to carry heavy loads, it is important to take into account the resistance of wood to crushing perpendicular to the grain. Frequently the area allowed for support of the ends of wooden beams is so small that crushing occurs while other proportions are ample for the load.

6. The ends of all wooden floor and roof beams, which rest on walls. shall be cut to a bevel of 3 inches in their depth.

7. Neither end of a floor or roof beam shall be supported on stud partitions, except in frame buildings.

8. All wooden floor and roof beams shall be properly braced with cross bridging. The distance between bridging or between bridging and bearing shall not exceed 8 feet. So far as possible knots or other imperfections shall be excluded from the bottom and top quarters of timber beams.

Timber stresses, Sec. 65, par. 4.

SECTION 77. WOODEN BEAMS SEPARATED FROM MASONRY CHIMNEYS.—1. No wooden beams or joists shall be placed within 2 inches of the outside face of a chimney or flue, whether the same be for smoke, air or any other purpose.

2. No woodwork shall be within 4 inches of the back face of the wall of any fireplace. Figs. 25 and 26.

3. For smoke flues of boilers and furnaces where the brick work is required to be more than 8 inches in thickness, the header beams shall be not less than 4 inches from the outside of the brickwork.

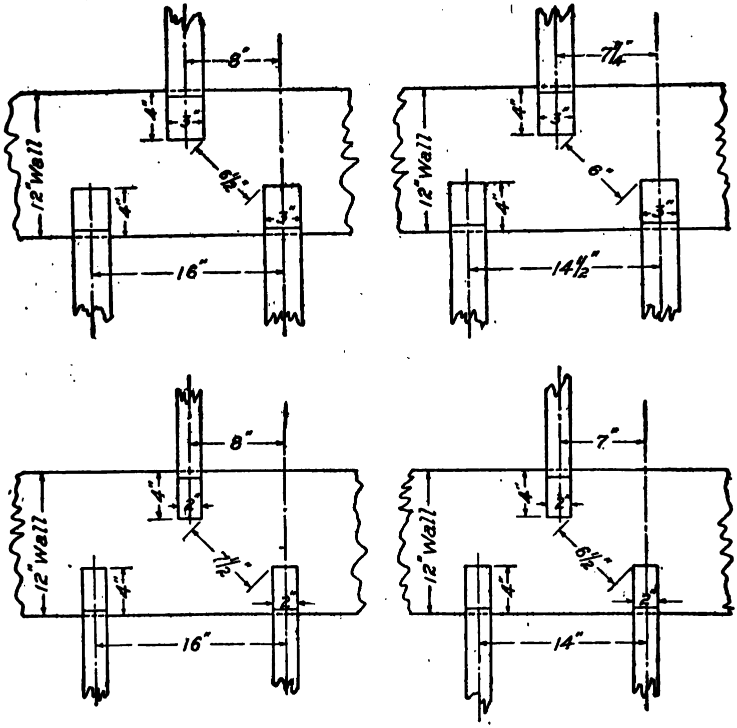

FIG. 24.—Diagram showing placing of floor beams in a wall to secure a separation of at least 6 inches between the ends

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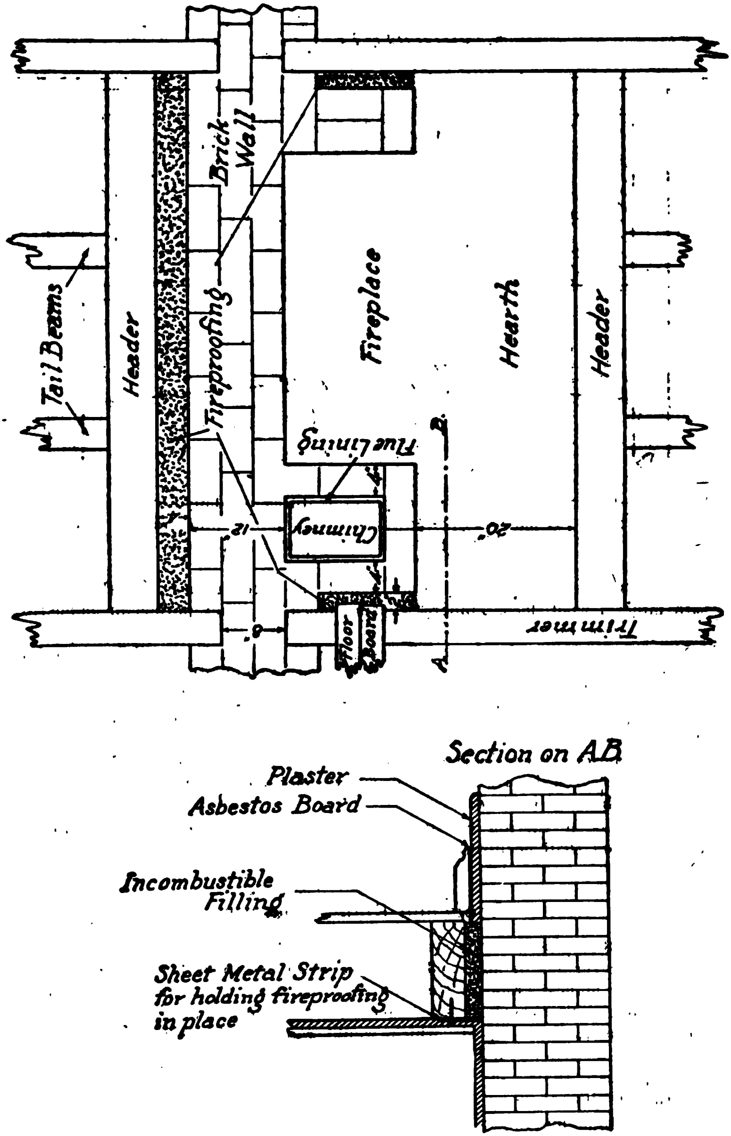

FIG. 25.—Fire-stopping around chimney and fireplace.

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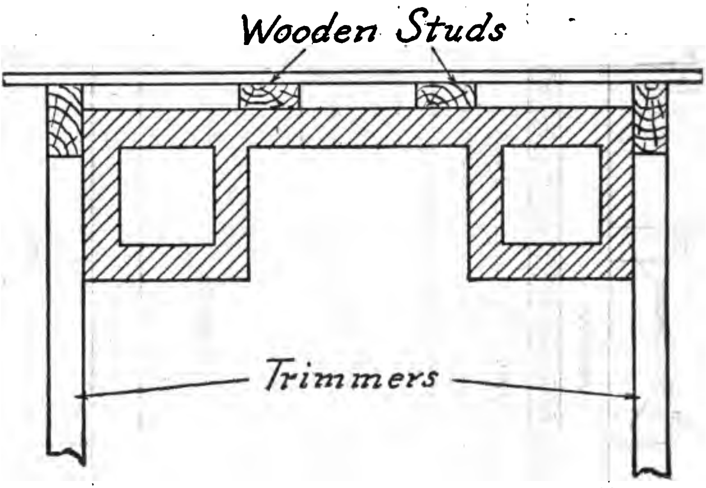

FIG. 26.—Diagram showing two common features of dangerous chimney construction. Woodwork placed against chimneys, and unlined flues.
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4. All spaces between the chimney and the wooden beams shall be filled with mineral wool, loose cinders, gypsum block, or other porous incombustible material. See Fig. 25.

NOTE.—The object of this filling of dead air spaces around a chimney before the flooring is laid, is to prevent an accumulation of shavings and other combustible material in them, also to prevent the danger of mice building nests there. The filling material should be porous to preserve the heat insulating advantage of the air cells, consequently brickwork, mortar, or solid concrete should not be used.

5. The header beam, carrying the tail beams of a floor, and supporting the trimmer arch in front of a fireplace, shall be not less than 20 inches from the chimney breast.

6. No wooden furring or studding shall be placed against any chimney, the plastering shall be directly on the masonry, or on metal lathing.

Roofs and Roof Structures

SECTION 80. ROOF COVERINGS.—1. All buildings except as given below shall have roof coverings of approved standard quality, such as brick, concrete, tile, or slate; or highest grade of tin roofing, or of asbestos shingles, or of built-up roofing felt with gravel or slag surface, or of built-up asbestos roofing; or other roofings of like grade which would rank as Class A or B, as listed by the Underwriters' Laboratories, Inc.

Exceptions:

(a) Dwellings;

(b) Frame buildings;

(c) Buildings not exceeding two stories or 30 feet in height and 2,500 square feet in area, and not used for factories, warehouses, or mercantile purposes.

2. The quality of roofing for all dwellings and other buildings exempted in paragraph 1, shall be as therein specified; or may be of a grade which would rank not lower than Class F, as listed by the Underwriters' Laboratories, Inc.

3. A layer of deadening felt at least 1/16 inch thick shall be placed between metal roofing and the supporting woodwork.

NOTE.—The purpose of the felt is to prevent quick ignition of the wooden decking when the roof is exposed to burning brands or radiated heat.

4. The wooden planking and sheathing of roofs shall not in any case be extended across side or party walls.

5. Any roof having a pitch over 60 degrees, placed on any building over 40 feet high, except towers or church spires as specified in Section 188, shall be constructed of iron or steel frames filled with fireproof material not less than 3½ inches thick, and shall be covered with approved roofing.

6. All flashings shall be of metal properly incorporated with the roofing material. Copper flashings are recommended.

7. The top and sides of dormer windows shall be protected the same as the roof.

SECTION 85. CORNICES AND GUTTERS.—1. On all buildings or structures within the fire limits the exterior cornices, inclusive of those on show windows and gutters, shall be of incombustible material. All cornices not built as a part of the walls, shall be secured to the walls with metal framing or anchors.

3. Outside of fire limits where buildings having masonry walls are placed nearer than 3 feet to a side or rear lot line, or 5 feet to another building, the cornices and overhanging eaves on the side or rear walls shall be of, or covered with, incombustible material. When such buildings are erected in rows, combustible cornices on the front shall be fire-stopped with incombustible material between each building.

NOTE.—The most vulnerable point of attack for an exposure fire of this kind is under the eaves, for the heat banks up there, and the woodwork is always highly combustible since never exposed to storms. With ordinary construction numerous cracks are almost certain to exist alongside the rafters communicating directly with the attic space which is usually difficult of access, and liable to be filled with combustible material. It is therefore important that the space above the plate and between the rafters be filled as tight as possible. Where masonry walls are used they should extend up to the underside of the roof boards.

SECTION 88. PROTECTION OF EXTERIOR WALL OPENINGS.—1. Every building within the fire limits, except churches and dwellings, shall have approved fire doors, or fire windows on every exterior opening above the first story, when fronting on a street or driveway less than 50 feet wide, or where another building or portion of the same building is within 50 feet of such opening; also all openings in the side and rear walls of the first story, except show windows, when less than 50 feet from another building. The walls of a building in the same plane or parallel planes and facing in the same direction as that in which the opening is situated, shall not be considered as coming within the intent of this rule.

NOTE.—It has been demonstrated many times that the heat from a burning building will break the windows and imperil an exposed building distant even 60 feet or more. The combustibility of the contents of the buildings and the direction of the wind would control results somewhat, but the height of the exposed building would have even greater influence upon its safety. The difficulty of a fire department maintaining its position in front of a vigorously burning building in a street 50 feet or less in width, with the wind blowing in that direction, is well known. If the fire fighting force cannot maintain such position the danger to the exposed building is apparent, and if the building is over 5 stories high the hazard of the fire entering the windows is greatly increased.

2. All openings in a side wall above and facing on the roof of an adjoining building of other than fireproof construction, shall be protected by fire doors or fire windows to a height of 50 feet above the roof measured in a vertical line. If the adjoining building has a fireproof roof, all openings in the said side wall shall be protected from the level of the adjoining roof to a height of 50 feet measured in a straight line from the adjacent edge of the nearest skylight or other opening in the adjoining roof, to the top of the opening in the wall.

3. All openings in a side wall above and facing on the roof of a building of other than fireproof construction which is separated from the side wall by a horizontal distance less than 50 feet, shall be protected by fire doors or fire windows from the roof level of the exposing building to a height of 50 feet measured from the top of the adjacent parapet wall to the top of the opening in the wall; or 50 feet from the adjacent edge of the nearest skylight or other opening in the roof of the exposing building, if the roof be of fireproof construction.

4. All exterior wall openings more than 75 feet above the curb in all buildings, shall be protected by fire doors or fire windows.

5. In business buildings over four stories or 55 feet in height, the windows which are not fire windows, shall have a distance of at least 3 feet between the top of a window sill, and the bottom of the lintel of a window directly beneath. No such window shall be arranged to open within 1 foot of the ceiling surface, but the wall construction between the window opening and the ceiling, may, if desired, be replaced by a fire window in fixed sash and frame.

NOTE 1.—The tendency of fire in a building to travel upwards from story to story by way of the windows is well known. This danger is reduced by separation of the openings through which flames may issue. The National Fire Protection Association recommends 5 feet between windows for a "Standard Building"; such separation is very desirable where it is possible to obtain it. The provision of at least a foot of space between a window head and the ceiling is for the purpose of banking the flames, and deflecting them downward as they escape to the outside air. The hazard can be still further reduced by making the whole upper half of such windows of wired glass in fixed metal sash and frames. Full size windows should be installed wherever possible.

NOTE 2.—The prevalent practice of enclosing factories and some commercial buildings almost entirely with glass, is dangerous. If plain glass be used, the construction is doubly unwise, for an uncontrolled fire in any of the lower stories is sure to reach the stories above by way of the windows. Even with wired glass the hazard is excessive for it is not a resistant to radiated heat, and there is always serious risk that combustible material in any story will be ignited from that cause.

6. Approved fire shutters may be substituted in place of the fire windows required in paragraphs 1, 2 and 3. In such cases at least one row in every three vertical rows of shutters shall be arranged to be readily opened from the outside, and a distinguishing mark satisfactory to the Chief of the Fire Department shall be provided on these shutters.

NOTE.—It is strongly recommended that all window openings exposed to buildings within 15 feet where considerable fire hazard exists, shall be protected by approved shutters or outside open sprinklers in addition to fire windows. The limit of resistance of a wired glass window is reached at about 1,600° F., when the glass will melt and drop from the sash. This temperature is frequently reached in an exposure fire.

7. Occupants of buildings shall close all fire doors, shutters, and windows at the close of business each day.

NOTE.—For complete details of construction and installation of fire doors, shutters and windows, see pages 367 to 433.

SECTION 89. PROTECTION OF INTERIOR WALL OPENINGS.—2. In buildings of all classes, all openings into halls or adjoining rooms from rooms in which paints, oils, varnishes, spirituous liquors, or drugs or other highly inflammable liquids or materials are stored for purpose of sale or otherwise; or in which manufacturing processes, or business operations are conducted which are generally recognized as hazardous as regards fire, shall be protected by self-closing fire doors, or fire windows.

Openings in fire walls, Sec. 29, par. 2.

Openings in fire exit partitions, Sec. 47, par. 4.

Openings in shafts, Sec. 90, par. 12 and 13.

Protection of Vertical Openings

SECTION 90. ENCLOSURES FOR STAIRWAYS, ELEVATORS, ESCALATORS AND OTHER SHAFTS IN FIREPROOF BUILDINGS.—1. All interior shafts containing stairways required to be enclosed by Section 45, paragraph 1, and except in dwellings, all shafts exceeding 6 square feet in area containing elevators, escalators, hoistways, chutes, ventilating ducts, or used for any other purpose, shall be continuously enclosed with fireproof walls or partitions built as follows:

(a) Brick or plain solid concrete not less than 8 inches in thickness for the uppermost 30 feet, increasing 4 inches in thickness for each lower section of 30 feet or part thereof; or 8 inches in thickness for the entire height when wholly supported at vertical intervals not exceeding 30 feet.

(b) Reinforced stone or gravel concrete not less than 6 inches in thickness for the uppermost 30 feet, increasing 2 inches in thickness for each lower section of 30 feet or part thereof; or 5 inches in thickness for the entire height when supported at vertical intervals not exceeding 20 feet and braced where necessary with lateral supports or suitable steel uprights.

(c) Reinforced cinder concrete not less than 5 inches in thickness for the entire height when supported at vertical intervals not exceeding 15 feet, and braced where necessary with lateral supports or suitable steel uprights.

(d) Semi-porous or porous terra cotta tile, or solid gypsum blocks not less than 6 inches in thickness for the entire height when supported at vertical intervals not exceeding 20 feet, and securely anchored by steel reinforcement encased in the construction.

Terra cotta tile shall have not less than two cells in its thickness, with shells and webs not less than ⅝ inch thick.

All openings in such partitions shall have substantial steel framing, the vertical members of which shall be securely attached to the floor construction above and below.

2. Enclosure partitions supporting floor loads shall be of materials and thickness required for bearing walls.

3. Portland cement mortar shall be used for all masonry work in shaft construction, except that gypsum mortar may be used to set gypsum blocks.

4. Concrete walls or partitions shall conform to the requirements of the sections on concrete construction.

5. The bottom of such enclosure, and the top when not extended through the roof, shall be of fireproof material not less than 4 inches in thickness.

6. When such shafts extend to the top story, they shall continue through the roof, and shall project not less than 6 inches above the roof surface. All such shafts shall be enclosed above the roof by at least 5 inches of brick, or stone concrete.

7. Every shaft which extends above the roof shall have a skylight, covering at least three-fourths of the area of the shaft.

Construction of skylights, see page 423.

8 All steel used to support shaft enclosures, as required in this section, shall so far as possible, be embedded in the fireproofing material, and shall be protected on all sides, in the manner required for steel in fireproo: buildings. See Section 112.

9. When the compartment that contains the machinery for operating an elevator communicates with an elevator shaft, it shall be enclosed with fireproof partitions as required for the shaft.

10. A shaft shall not contain more than two elevators. The separating partitions shall be not less than 2 inches thick.

11. A stairway and elevator shall not be permitted within the same shaft enclosure.

12. All door openings into such shafts shall be protected by fire doors and shall be self-closing except for elevator doors. No glass shall be permitted in such doors, except when doors in elevator shafts open upon an enclosed hallway a wired glass panel not exceeding 2 square feet may be provided in each door. Care shall be exercised to insure that all such doors shall fit the opening as closely as practicable.

NOTE.—It is necessary that sliding doors on elevator shafts be made to fit snugly, otherwise in case of fire the shaft fills with smoke and hot gases and becomes untenable and dangerous. The accumulation of such hot gases is very liable to cause an explosion.

In factories and warehouses where elevator shafts open directly into a work or storage room, no wired glass shall be permitted in the doors. The size of such door openings shall not exceed 5 feet 4 inches by 7 feet 6 inches.

13. Windows shall not be permitted in shaft enclosures, except those opening to the outside air, and which are at least 3 feet distant from any other opening; all such windows shall be stationary or automatic closing fire windows.

14. Where an elevator, escalator, or stairway as required in paragraph (1), connects two floors only in a building, it shall be enclosed in the same manner as for a continuous shaft, except that it may be left open in one story if enclosed in the other. Such elevator or escalator shall not be included in calculations for required means of exit, and no such stairway shall be considered as an exit from more than one floor.

NOTE.—The reasons for excluding elevators and escalators as exits are obvious. The reason for restricting the above described stairway as an exit for one floor only, is that if it were used by people coming from a floor above they would be obliged to pass through the open room at the head of the stairway, and this would be extremely dangerous if that room were afire.

Fire doors and windows, Sec. 88.

SECTION 91. ENCLOSURES FOR DUMBWAITERS AND OTHER SHAFTS NOT EXCEEDING 6 SQUARE FEET IN AREA IN FIREPROOF BUILDINGS.—1. All dumbwaiter and other shafts or chutes not exceeding 6 square feet in area, excepting dumbwaiter shafts which do not extend more than one story above the cellar or basement floor in dwellings, shall be continuously enclosed by partitions of brick, terra cotta, concrete, metal lath and cement plaster, gypsum blocks, or other approved fireproof material not less than 3 inches thick, which may meet the test specified in Section 174, paragraph 4. Such walls or partitions shall rest upon incombustible foundations, and shall be braced between floors with approved incombustible framing. Gypsum blocks may be set in gypsum mortar; all other blocks shall be set in Portland cement mortar.

2. When dumbwaiter or other small shafts are constructed of blocks or tile, all corner blocks or tile shall be held by metal angle clips or anchors, or be secured by other approved means.

3. Where a dumbwaiter shaft extends into the cellar or basement of a building, it shall be enclosed in that story with walls of masonry not less than 5 inches thick.

4. The bottom of such shaft shall be of fireproof material, and where such shaft does not extend through the roof, the top of the shaft shall be of fireproof material of at least the thickness of the enclosing partitions.

5. When such a shaft penetrates the roof it shall project at least 6 inches above the roof, and shall be covered with fireproof material and have a skylight covering at least three-fourths the area of the shaft.

6. All openings in dumbwaiter shafts shall be provided with approved self-closing fire doors.

7. No woodwork other than the guides and car shall be permitted in the construction of any such shaft.

Dumbwaiter shafts in frame buildings, Sec. 190, par. 4.

Section 92. Light and Vent Shafts.—1. The walls of all light or vent shafts, whether exterior or interior, shall extend not less than 3 feet above the level of the roof and be coped.

2. In all buildings other than private dwellings and frame buildings, all windows opening into light and vent shafts shall be protected by fire windows.

Section 93. Enclosures for Stairway, Elevator and Other Shafts in Non-Fireproof Buildings.—1. In non-fireproof buildings of ordinary construction, all shafts defined in Sections 90, 91 and 92, shall be constructed as specified in those sections, except as herein provided, and except that the enclosing walls or partitions may be of semi-porous or porous two cell terra cotta, or of solid gypsum blocks, not less than 5 inches in thickness; or 4 inches of reinforced concrete. The thickness of new material permitted under test as specified in Section 90, shall be not less than 4 inches. Such partitions shall be supported by steel structural framework at intervals not exceeding 20 feet. In all respects the reinforcement, bracing, and protection of steelwork shall conform to the requirements of Section 90.

Any woodwork other than guides and car, exposed on the inside of the shaft, shall be covered with metal, or metal lath and ¾ inch of cement or cement-tempered plaster, or their equivalent.

2. Dumbwaiter and other small shafts shall be constructed the same as required in Section 90, except as provided in paragraph 3.

3. Every shaft in a non-fireproof building that extends to the top floor shall continue through the roof and at least 3 feet above it. In all other respects, shafts in non-fireproof buildings of ordinary construction, shall conform to the requirements of Sections 90 and 91.

4. When such partitions rest upon timber construction, they shall be fire-stopped with incombustible material the full depth of the floor beams at each floor level in the manner specified in Section 97, paragraphs 2 and 3. The fire-stopping shall be placed to form a complete cut-off between the interior of the building and the shaft.

Enclosures for stairway and other shafts in frame buildings, Sec. 190, par. 4.

When stair hallway shall be enclosed same as stairway, Sec. 116, par. 4.

Miscellaneous Construction Requirements

Section 96. Floor Lights.—Floor lights shall have metal or reinforced concrete frames, and shall be of the same strength as the floors in which they are placed. The glass in floor lights shall be not less than ¾ inch in thickness, and if any glass measures more than 16 square inches, there shall be a wire mesh, either in the glass or under it.

SECTION 97. FIRE-STOPPING.—1. Furred Walls.—For all walls furred with wood the masonry between the ends of wooden beams shall project the thickness of the furring beyond the inner face of the wall for the full depth of the beams; or a course of masonry above and below the beams, shall project the full thickness of the furring beyond the face of the wall. Fig. 27. In cases where floor beams are parallel to a wall furred with wood, there shall be a space of not less than 2½ inches between such wall and the nearest beam. This space shall be filled in solidly with brickwork, or concrete for the full depth of the floor beams.

2. Studded-off Spaces. Where walls are studded-off, the space between the inside face of the wall and the studding at the floor level shall be fire-stopped with brickwork or other approved fireproof material. The beams directly over the studded-off space shall be deadened with not less than 6 inches of fireproof material, which shall be laid on boards cut in between the beams. The under side of such beams shall be protected by a covering of metal lath, or plaster board, and plastered to a total thickness of ¾-inch.

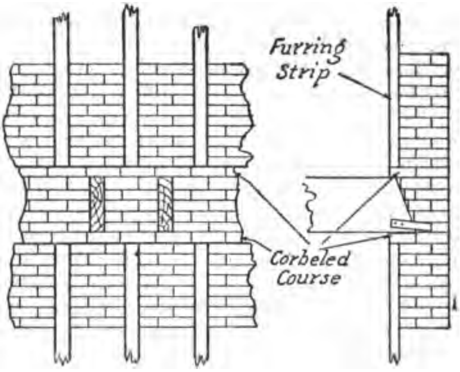

FIG. 27.—Method of fire-stopping furred brick walls.

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3. Partitions.—Where stud partitions rest directly over each other, and cross the wooden floor beams at any angle, they shall run down between the floor beams and rest on the top plate of the partition below, and shall have the studding filled in solid between the uprights the depth of the floor beams and at least 4 inches above each floor level with brickwork or other approved incombustible materials. Such stops shall be arranged to entirely separate the spaces between floor beams and those between partition studs in a manner to effectually cut off draft openings from story to story. Fig. 28.

When sliding doors are pocketed in partitions, care shall be exercised to insure that such pockets be completely fire-stopped at top and bottom.

4. Wainscoting.—The surface of the walls or partitions behind wainscoting shall be plastered flush with the grounds and down to the floor line.

5. Stairs.—The space between stair carriages shall be fire-stopped at least once in the middle portion of each run.

6. No fire-stops shall be covered or in any manner concealed from view until approved in writing by the Superintendent, who shall inspect the same within 48 hours after receiving written notice, Sundays and legal holidays excepted.

7. Pipes, Shafts and Belts.—All exposed pipes or power shafting passing through any floor or wall shall have the surrounding air space closed off at the ceiling and the floor line; also on each side of the wall by close fitting metal caps. See Note, Sec. 183. In fireproof construction it is preferable to have the pipes or shafts fit neat in the floor or wall.

All belt drives through floors shall be continuously enclosed by steel framework covered with metal lath and cement plaster, or other approved incombustible material. Where possible all such belts shall be placed in a special shaft.

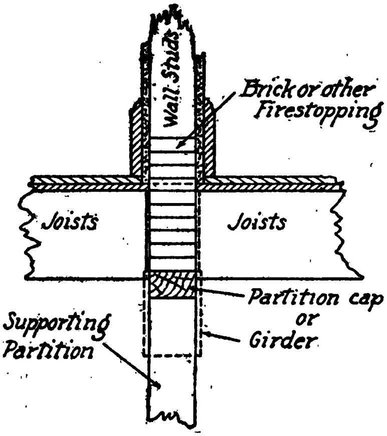

FIG. 28.—Fire-stopping of partitions.

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8. Ducts and Chases.—Ducts, chases, or shafts for pipes, wires, cables and for similar purposes, shall be constructed as required in Sections 90-93, or shall be fire-stopped at each floor.

Fire-stops around chimneys, Sec. 77, par. 4.

Fire-stops in frame buildings, Sec. 190, par. 5.

SECTION 98. REQUIREMENTS IN NON-FIREPROOF BUILDINGS USED FOR BUSINESS AND RESIDENCE.—All ordinary construction non-fireproof buildings of Classes C and D over two stories or 35 feet high, where the lower stories or portions thereof are used for business, and the stories above for residence purposes, shall have all partitions and ceilings separating the business portions from the residence portions, covered with metal lath or ½-inch fibre plaster board and plastered with cement or cement-tempered plaster to a total thickness of ¾ inch; or plaster board may be covered with sheet metal. Other equivalent fireproofing may be used. There shall be no windows in such partitions, and all other openings shall be protected by fire doors.

Stairway, elevator and other shafts in such buildings, shall be constructed in conformity with requirements of Section 93.

Fire-stops shall also be provided at the line of the ceilings to completely cut off all communication to floors above through hollow stud partitions or side walls, as required by Section 97, paragraphs 1, 2 and 3.

NOTE.—Sheet metal, unless backed by an unbroken layer of at least ½ inch of plaster or plaster board, is not considered equivalent to either of the above mentioned methods of protection.

Fireproof Construction, and Fireproofing

SECTION 110. GENERAL REQUIREMENTS FOR FIREPROOF BUILDINGS.—1. The walls of every fireproof building shall be constructed as specified in Sections 21-30. The floor and roof construction shall conform to the construction and test requirements specified in Sections 111-113. Reinforced concrete buildings constructed as specified in Part XXII, shall be classed as fireproof construction.

2. The space between the floor arches or slabs and the floor finish shall be solidly filled with concrete as specified in Section 172. The filling beneath wooden flooring shall be made flush with the under side of the floor boards.

3. In buildings of Class E, except stables, also in apartment houses, clubs and hotels, when of fireproof construction, the floors shall be made impervious to water; they shall also be arranged to drain to scuppers or interior drainage pipes, provision being made to discharge water at the rate of 300 gallons per minute per each 1,000 square feet of floor area.

NOTE.—This requirement is made on the assumption that in case of a fire there would be at least one hose stream playing upon each 1,000 square feet of floor area. A certain amount of such water would find its way naturally to stairway and elevator shafts, but with well constructed shaft doors the flow of water at such outlets would be greatly retarded, except when the doors were open for fire fighting purposes or for other cause. Accumulation of water upon an ordinary floor is sure to produce very serious damage to stock, fittings, and decorations upon all floors below. It is not infrequent that the major portion of the resultant loss from a fire in a fireproof building, is due to water rather than fire. Terra cotta and cinder concrete floor construction as usually installed, leak badly when flooded with water. When a fire occurs in any story of a building having such construction, and considerable water is used to extinguish it, the property loss in stories below due to water is always high unless waterproof floor surfacings are used. The free flow of water through such floors is seriously criticised by firemen. It is not only extremely disagreeable, but it hampers their work and introduces the danger of falling ceilings as well as possibility of overloading floors which are heavily stocked with absorbent material.

Incombustible floor surfacings should be made continuous with the base on all sides of the room to a height of at least 6 inches. Flashings should be provided around all openings through floors except those where a discharge of water would produce a minimum of damage. If scuppers are not desirable to remove surplus water, drainage pipes connecting to gratings located in the baseboard or at other suitable points may be provided. When floors have a granolithic finish, care should be exercised to make the mixture as dense as possible. The addition of 10 to 15 per cent by volume of hydrated lime is recommended to reduce porosity. Wooden floor surfacing should be made as waterproof as practicable. Waterproof paper is sometimes used between the layers of rough and finished flooring, but this increases the danger from dry rot, unless care be exercised to have the sleepers and rough flooring thoroughly dry before sealing it down with the paper. Antiseptic treatment is the most reliable. See Note to paragraph 5. Similar precautions shall be taken around openings through wooden floorings as for other floorings, and the joints between walls or partitions shall be made as tight as practicable. The lowest floor of the building should be provided with adequate facilities for removing surplus water.

4. Except as permitted in Section 45, paragraph 1, all shafts and public hallways shall be enclosed and separated from the rest of the floor space by fire-resistive enclosures, as specified in Sections 90 and 115, and shall have floor surfaces and trim of approved incombustible material. The stairs and stairway landings shall be of approved incombustible material.

5. No woodwork or other combustible material shall be used in the construction of any fireproof building, except wooden floor sleepers, grounds, bucks, and nailing blocks when entirely embedded in incombustible material; also the finish flooring, and interior doors and windows, when not otherwise specified, with their frames, trim, and casings; also interior finish when backed solidly with fireproof material, may be of wood. Wooden wainscotings more than 3 feet high, or wooden ceilings, shall not be permitted.

NOTE 1.—Attention is called to the grave danger of dry rot attacking floor sleepers which are embedded in concrete and then sealed from the air by the floor covering. Instances of rapid decay and serious damage from this cause are numerous. Well seasoned heartwood timber is best suited for this purpose, and antiseptic treatment is recommended. Coal tar antiseptics are not suitable for this purpose in most buildings. The odor and the oily surfaces are disagreeable, and the danger from fire is increased. Wood treated with zinc chloride or corrosive sublimate is not subject to such criticism.

NOTE 2.—For the highest grade of fireproof building, incombustible surface flooring and metal trim should be used. Buildings of such construction are being erected in numerous cities, and are considered first-class investments.

6. Exterior wall openings shall be protected as required in Section 88.

SECTION 111. FIREPROOFING, FLOOR AND ROOF CONSTRUCTION.—1. Fireproof construction between steel floor or roof beams, shall consist of segmental arches of brick or concrete, or of segmental or flat arches of hollow terra cotta, or reinforced cinder, stone, or gravel concrete; or of such other equally fire-resisting material or construction as may be approved after fire, water, and strength tests.

2. All segmental arches shall have a rise of 1¼ inches to the foot of span. Steel tie-rods of proper size, spacing, and location shall be used in all arches to properly resist the thrust. Such tie rods shall be completely encased to a depth of at least 2 inches in fireproofing material which shall extend into and be anchored to the arch.

NOTE.—Tie-rods are an important feature of segmental and flat arch floor construction between steel beams. In general the rods should be placed as near the bottom flanges of the beams as consistent with proper protection by fireproofing. It is good practice to double the number of tie-rods for all outer arches.

Tie-rods in reinforced concrete fireproof construction, Sec. 171.

3. The spacing of floor or roof beams in fireproof construction shall not exceed 8 feet on centers except when the slabs between them are composed of reinforced stone or gravel concrete, in which case they shall be limited by the design.

4. Brick Arches.—Segmental arches of brick shall have a thickness of not less than 4 inches for spans of 5 feet or less, and 8 inches for spans exceeding 5 feet and not exceeding 8 feet. Brick arches shall be composed of good, hard common or hollow brick. The brick shall be laid to a line on the centers and properly and solidly bonded; each longitudinal line of brick shall break joints with the adjoining lines. The arches shall spring from suitably designed solid skewbacks made of the same materials as the arches, and be properly keyed. The brick shall be well wet before laying, and the joints solidly filled with mortar.

5. Terra Cotta Arches.—Hollow terra cotta tile used for floor or roof arches shall be hard burned or semi-porous and of uniform density and hardness. All terra cotta arches shall be properly keyed. The key blocks shall always be placed within the middle third of the span.

Segmental arches shall have sufficient depth between the top and bottom faces to carry the load to be imposed, but not less than 6 inches. The tile shall have at least two cellular spaces in the depth.

Flat arches shall have a depth of not less than 1¾ inches for each foot of span between the beams, this not to include any portion of the depth of tile that projects below the under side of the beams. The total depth shall in no case be less than 9 inches, and the tile shall have not less than three cellular spaces in the depth.

The shells of arch blocks shall be not less than ¾ inch in thickness, and the webs shall be not less than ⅝ inch in thickness. Every arch block shall have at least one continuous vertical internal web for each 4 inches in width. There shall be rounded fillets at all internal intersections. The skewbacks of all hollow tile arches shall be of such form and section as to accurately fit the beams and properly receive the thrust of the arches, and shall have shells at least 1 inch thick, and webs not less than ¾ inch thick.

The safe working load on terra cotta arches shall be determined by design or by test. The allowable extreme fibre stress in compression in terra cotta floor tile shall be taken as 500 pounds per square inch on net section.

7. Roofs.—Hollow terra cotta or concrete tile, or solid gypsum blocks, may be used for fireproofing between the steel framework of roof construction; but such tile or blocks shall be not less than 3 inches thick, and the supporting steel members shall be spaced not more than 25 inches on centers. When solid blocks or tile are properly reinforced to resist the bending stresses, the steel supporting members may be spaced not to exceed 30 inches apart. The bottom flanges of steel members shall be protected as elsewhere provided.

Thickness of stone concrete roofs, Sec. 137.

Thickness of cinder concrete roofs, Sec. 169.

Roof coverings, Sec. 80.

SECTION 112. FIREPROOFING, PROTECTION OF STRUCTURAL MEMBERS.—1. Protection of Wall Columns.—All columns which support steel girders carrying exterior walls, and all columns which are built into walls and support floors only, shall be protected against corrosion by a coating of Portand cement mortar at least ¼ inch thick, and against moisture and fire by a casing of masonry, which shall be not less than 4 inches of brick or 3 inches of concrete on all surfaces; all to be well bonded into the masonry of the enclosing walls.

NOTE.—Stonework is not reliable protection for steelwork against fire. A fire of only moderate intensity is practically sure to cause it to be ruined by spalling, and the metal structural members behind it may thereby be exposed.

2. PROTECTION OF WALL GIRDERS.—The wall girders shall have a casing of Portland cement mortar and the same masonry protection as required for wall columns, all to be securely tied and bonded; but the extreme outer edge of the flanges of beams, or plates or angles connected to the beams may project within 2 inches of the outside of surface of such casing. The inside surfaces of the girders shall be similarly protected by masonry, or if projecting inside the walls, they shall be protected by concrete, terra cotta, or other approved fireproof material not less than 2 inches thick.

3. All metal structural members which support loads or resist stresses, other than those provided for by the two preceding paragraphs, shall have a protection of fireproofing as herein specified. The protection material shall be brick, concrete, terra cotta, or gypsum block. Concrete shall be of the quality prescribed in Sections 162-168; terra cotta may be solid or hollow, and shall be porous or semi-porous, neither shells nor webs shall be less than ⅝ inch thick; gypsum blocks shall be solid and of quality approved by the Superintendent. Plaster shall not be considered a part of any required fireproofing for metal structural members except where specifically mentioned as such. See paragraph 8, also Section 114.

4. All bricks or blocks used for fireproofing shall be set in Portland cement mortar, except that gypsum blocks may be set in gypsum mortar. See note to paragraph 5, Section 115.

5. Interior Columns.—(a) The protection shall cover the columns at all points to a thickness of not less than 3 inches and be continuous from the base to the top of the column. The extreme outer edges of lugs, brackets, and similar supporting metal may project to within 1 inch of the outer surface of the protection.

NOTE.—Much has yet to be learned regarding the necessary thickness and methods of application of different column coverings to produce efficient fire protection. The investigations on this subject now in progress at the Underwriters' Laboratories in Chicago, will furnish much needed information. When secured, it may justify changes in the requirements herein made.

(b) If brick or blocks are used for fireeproofing columns, they shall be accurately fitted, laid with broken joints, and all spaces between the outside layer and the metal solidly filled with masonry; or a concrete filling may be used. No voids between the metal and the protecting casing shall be permitted.

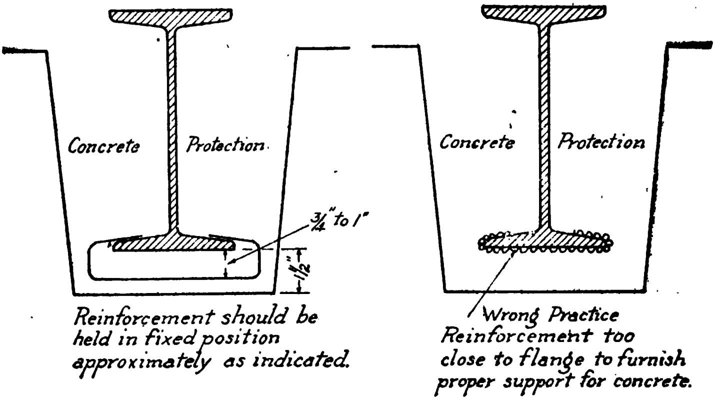
(c) Galvanized steel wire not smaller than No. 12 gauge, shall be securely wrapped around block column coverings so that every block is crossed at least once by a wire. The wire shall not be wound spirally around the column, but each turn or band shall be a separate unit and shall be twisted tightly or otherwise securely bound. Other equivalent anchorage may be employed if approved. No block used for this purpose shall exceed 12 inches in vertical dimension.

NOTE.—Any method which would securely lock the blocks in place, or hold them by substantial interior metal ties, would be superior to the wire wrapping above described.

(d) Columns located in damp places shall receive a coat of at least 1 inch of Portland cement mortar before application of the fireproofing.

(e) Columns made of steel or wrought iron pipe filled with concrete, shall be protected by at least $1\frac{1}{2}$ inches of fireproofing.

(f) Where the fireproofing of columns is exposed to damage from trucking



Reinforcement should be held in fixed position approximately as indicated.

Wrong Practice Reinforcement too close to flange to furnish proper support for concrete.

FIG. 29.—Diagrams indicating proper and improper reinforcement for concrete fire protection to bottom of beams.

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or handling of merchandise, the fireproofing shall be jacketed on the outside for a height of not less than 3 feet from the floor with metal or other approved covering.

6. Protection of Steel Girders and Beams.—(a) The protection of the webs and bottom flanges of girders, and all members of trusses shall have a thickness of not less than 2 inches at all points. The protection of the webs and bottom flanges of beams, lintels, and all other structural members shall be not less than 1½ inches at any point.

(b) If hollow terra cotta tile be used for protection, the lower flanges of beams and similar members shall be encased either by lugs which form part of the skewbacks and extend around the flanges meeting at the middle; or by tile slabs held in position by dove-tailed lugs projecting from the skewbacks. In either case care shall be taken to insure that all joints be solidly filled with mortar.

7. Concrete protection for all structural members shall be held in position by suitably designed interior steel anchors hooked securely around the flanges or angles of the members, at intervals not exceeding 8 inches apart; these anchors shall be not less than ⅛ inch in thickness if flat or 1/10 inch in diameter if of wire, and shall be located at a distance not less than ¾ inch, or more than 1 inch from the outside surface. Fig. 29. Provision shall be made to prevent displacement of anchors while concrete is being deposited. When the flange width of steel members exceeds 6 inches, the wire used for anchoring the concrete protection shall be not less than ⅛ inch diameter.

8. Steel angle or channel struts, or other structural framing not elsewhere provided for, which are used for support in any wall, partition, or other construction, shall be fireproofed as required in this section, or in Section 115, paragraph 4.

9. Metal fronts on the exterior of buildings over one story high shall be backed up or filled in with masonry not less than 8 inches thick.

SECTION 113. MISCELLANEOUS FIREPROOFING PROVISIONS.—1. Defective or damaged fireproofing materials shall not be used. All fireproof construction injured or damaged after being erected shall be repaired to the satisfaction of the Superintendent before any filling or finish is placed over same.

2. No pipes, wires, cables or other material shall be incased within or embedded in the required fireproof protection of columns or other structural members.

3. All metal lath and plaster ceilings shall be supported by hangers or clamps attached to the floor or roof construction in an approved manner. Such supports shall be of such section and weight as will support the wet plaster without deflecting more than 1/30 inch per foot of span.

4. All studding for metal lath partitions or wall furring shall be made from steel stock weighing not less than 0.5 of a pound per lineal foot, shall be spaced not over 16 inches center to center and shall be securely fastened to the floor and ceiling construction.

5. Metal lath shall be of galvanized steel weighing not less than 54 oz. per square yard. Wire lath shall be not less than No. 20 gauge, and sheet metal lath not less than No. 24 gauge. Metal lath shall be laced to the supporting furring or studs at intervals not exceeding 6 inches.

6. After floors are constructed, no opening greater than 2 square feet shall be cut through them unless suitable metal framing or reinforcing is provided around the opening. After pipes or conduits are in place, all openings around them shall be filled in solidly with fireproofing material unless approved close fitting indivdual sleeves are provided as specified in Section 97, paragraph 7.

SECTION 114. PROTECTION OF METAL STRUCTURAL MEMBERS IN NON-FIREPROOF BUILDINGS.—Steel girders and steel or iron columns which support masonry walls, other than those facing upon a street, shall be protected by at least 2 inches of fireproofing of the same materials and applied in the manner specified in Section 112; or by 2 inches of metal lath and cement plaster; the latter being applied in two layers with an air space between them. All other iron or steel columns shall be protected by at least 1 inch of metal lath and cement plaster or its equivalent. The lath shall be of quality specified in Section 113, paragraph 5.

NOTE.—The protection of metal structural members in non-fireproof buildings is made obligatory only for members supporting walls and main floor sections which in a fire are likely to collapse suddenly with serious danger to firemen and wrecking of the building.

It is very desirable, however, that other metal members which support important parts of a non-fireproof building, such as roof beams and trusses, should have at least a minimum protection of 1 inch of metal and cement plaster, or other equivalent protective material.

It is well known that steel begins to lose its strength at about 500° Fahr., and at 1,000° Fahr., approximately 70 per cent of its strength is gone. Temperatures such as these are easily reached in an ordinary fire, and if maintained even for a short time are almost sure to produce collapse of exposed steel structural members. Loaded cast iron columns are very liable to fracture and collapse when highly heated, especially when struck by a stream of water. A simple sub-standard protection as here suggested would prevent such failures, and might easily save a building from complete ruin.

Heavy timber construction will resist collapse from fire better than unprotected steel work. The wooden members will burn and help spread a fire, but it takes considerable time to burn them deep enough to reduce the strength sufficient to cause failure.

SECTION 115. PARTITIONS IN FIREPROOF BUILDINGS.—1. In fireproof buildings, all partitions enclosing public halls or separating the spaces occupied by different tenants, and all other permanent partitions, shall be built not less than 4 inches thick, of solid or hollow brick, terra cotta, concrete, or gypsum blocks or tile; or not less than 3 inches thick of reinforced concrete or solid metal lath and cement plaster; or of such other incombustible materials and thickness as shall meet the requirements of the partition fire test. The required thickness for block or tile partitions shall be exclusive of plaster. All such partitions shall be securely fastened to the fireproof construction of the floor and ceiling. All bricks, blocks or tile shall be laid with broken joints.

2. All partitions not enumerated above shall be of incombustible materials, except for woodwork permitted in Section 110, paragraph 5.

3. All partitions in fireproof buildings shall be independently supported at each floor level, and where lateral support is not sufficient they shall be stiffened by such steel reinforcement encased in the construction as the Superintendent may require and approve.

4. Structural steel members necessary for supporting a partition, or for framing doorways or other openings through it, shall be protected by at least 1 inch of fireproofing. Cement plaster, or cement-tempered plaster may be accepted for this purpose if properly keyed.

NOTE.—The importance of fireproofing structural framework, or reinforcing members in partitions, must not be ignored or underestimated. It is a fatal weakness in a large proportion of otherwise very efficient constructions of this class. In nearly every fire of any magnitude, involving high grade construction, fire resistive partitions are rendered worthless by excessive expansion of unprotected steel framework contained in them. In some cases expansion joints in such steel members have been used with success.

5. Reinforced concrete for partitions shall be as required in Sections 120-125 and 162-168. Terra cotta tile shall be porous or semi-porous in quality, and

if hollow, shall have two cells in the thickness, with the thickness of shells inclusive of plaster key, not less than ¾ inch, and the thickness of webs not less than ⅝ inch. The shells and webs of hollow gypsum or concrete blocks or tile shall be not less than ¾ inch. Gypsum shall be used only in dry locations. Metal lath and studding shall conform to the requirements of Section 113.

NOTE.—Gypsum blocks, or so-called "plaster blocks," or "cinder plaster blocks," have a high percentage of absorption, and when wet they lose considerable of their strength. They should not be used in contact with damp surfaces, or where likely to become wet. Such blocks are also liable to deteriorate when subjected to temperatures in excess of 200° Fahr. for considerable periods of time. They should not be used where such unusual temperatures prevail.

6. All openings in public hallway partitions shall be protected by approved fire doors or fire windows. Approved fire doors may be permitted in a partition separating tenants in a building, but no glass shall be permitted in openings in such partitions.

NOTE.—Openings of any kind in partitions separating tenants are to be avoided wherever possible. They are always a source of danger in case of fire.

7. If a stair hallway be considered as a part of the stairway, and the latter is not separately enclosed as required by Section 90, then the enclosing partitions for the hallway shall be considered as the stairway shaft, and shall be built according to the requirements of Section 90.

8. If the partition surrounding a public hallway be erected in accordance with the requirements for a fire exit partition, it may be considered as a horizontal exit for an occupancy equal to area of the hallway in square feet divided by three.

NOTE.—The requirements for partitions specified in this section, should not be interpreted to exclude the use of cork or other material not readily flammable, when used in refrigeration plants for insulating purposes, and when installed in a manner satisfactory to the Superintendent.

Fire exit partitions, Sec. 47.

Horizontal exits, Sec. 46, par. 2 (c).

SECTION 116. FIRE-RESISTIVE PARTITIONS IN NON-FIREPROOF BUILDINGS.—1. In non-fireproof buildings of Classes B, C, D, and E, all partitions enclosing public hallways, or separating the spaces occupied by different tenants, shall either be built as required in Section 115, or they may be built of not less than 3-inch approved solid or hollow partition blocks or tile, or by 3-inch hollow or 2-inch solid metal studding and lath with cement plaster, or by 2 x 4 inch wooden studding with metal lath and ¾ inch of cement or cement-tempered plaster on each side; or of any other materials and thickness as shall meet the requirements of the partition fire test. Wooden studs shall be set with the 4-inch dimension at right angles to the plane of the wall.

2. All such partitions shall be fire-stopped the full depth of the floor beams at each floor level in the manner specified in Section 97.

3. Openings in such partitions shall be protected by fire doors and windows as specified in Section 115.

4. The principles governing hallway partition construction as stated in Section 115, paragraphs 7 and 8, shall apply to the construction of like partitions in non-fireproof buildings, consistent with the requirements of Section 93 for such construction.

Reinforced Concrete Construction

General Requirements

SECTION 117. DEFINITION.—The term "reinforced concrete" in this Code shall mean an approved concrete mixture in which steel is embedded in such a manner as to resist the tensile stresses and to add rigidity and strength to concrete in compression.

SECTION 118. APPROVED FOR ALL TYPES OF BUILDINGS.—Reinforced concrete will be approved for all types of building construction, provided the design conforms with good engineering practice, and the working stresses do not exceed those herein specified. The construction shall meet the requirements of this Code in all respects, and in addition shall conform to such other rules as may be issued by the Superintendent of Building Construction or State authorities having jurisdiction.

SECTION 119. CONSTRUCTION PLANS AND SPECIFICATIONS.—1. The plans and specifications required to be filed with the Superintendent shall be accompanied by stress computations and descriptions showing the general arrangement of the entire construction in all important details, including the size, length, and points of bending of all reinforcement, the qualities, proportions, and methods of mixing the materials used in the concrete and the dead and live loads each floor is designed to carry.

2. All such plans and specifications shall be signed by the architect, engineer, contractor or person applying for the permit. In no case shall the construction deviate from the approved plans and specifications except by written consent of the Superintendent of Building Construction.

Specifications for Materials

SECTION 120. QUALITY OF CONCRETE.—1. The concrete shall consist of a mixture of a plastic or viscous consistency of one part of cement to not more than six parts of aggregate, fine and coarse, either in the proportion of one part of cement, two parts of sand and four parts of stone or gravel, or in such proportion as to produce a maximum density. Such concrete shall develop a crushing strength of at least 2,000 lbs. per square inch at 28 days when made under laboratory conditions of manufacture; the materials and consistency being practically the same as that used in the field. Test specimens shall be removed from moulds as soon as well set and stored in damp sand until tested.

NOTE.—For important work the best proportions of the component materials should be carefully determined by density experiments and the relative proportions changed to meet varying sizes of fine and coarse aggregate to secure maximum density.

The concrete mixture should be of such consistency that tamping will readily bring water to the surface, but should not be so wet that the coarse aggregate will tend to separate and settle at the bottom. Excess of water usually leaks from the forms carrying cement with it, thus weakening the concrete, and leaving it porous or "honey-combed."

Weight of concrete, Sec. 63.

2 Concrete in the proportion of one part of cement to four and one-half parts of aggregate, which may be desirable for special work such as columns, shall develop a crushing strength of not less than 2,400 pounds per square inch at 28 days, and the working stress of such concrete may be increased 20 per cent over that permitted elsewhere in this Part.

3. Each test shall consist of a set of at least three duplicate specimens in the shape of cylinders with a height of double the diameter; or cubes having a least dimension of 6 inches. Cubes shall be tested standing on bed

and 75 per cent of the resulting test strength shall be assumed as the strength of the standard cylinder specimen 8 inches in diameter and 16 inches high. The average of the three tests shall be taken as the result for record. The smallest dimension of the test piece should be at least four times the size of the coarsest particle of stone.

NOTE.—The standard form of concrete test specimen generally recommended by testing authorities is a cylinder 8 inches in diameter and 16 inches high. This shape of specimen is advised. Moulds for such specimens are easily made by splitting sections of ordinary stove pipe.

Quality of cinder concrete, Sec. 167.

SECTION 121. QUALITY OF CEMENT.—All cement used in reinforced concrete shall be Portland cement.

SECTION 122. QUALITY OF FINE AGGREGATE.—1. Fine aggregate shall consist of sand, crushed stone, or gravel screenings, passing when dry a screen having ¼ inch diameter holes and not more than 6 per cent passing a sieve having 100 meshes per lineal inch. It shall be clean and free from quicksand, vegetable loam, perishable organic matter, or other deleterious materials.

NOTE.—Sand with a gradation of grains from fine to coarse is desirable. Silt in sand which contains a small percentage of organic materials, such as vegetable loam, renders the aggregate unfit for use. Clay in small quantities, not exceeding 6 per cent, is not necessarily injurious, and may be beneficial by increasing the density. Pit and stream sands are usually of good quality, but drift sand is ordinarily of too fine a grain to make good concrete. It is recommended that the mesh composition of sand shall be such that 100 per cent passes a ¼-inch mesh sieve; that not more than 75 per cent, and not less than 40 per cent, by weight, passes a 20-mesh sieve; that not more than 30 per cent, and not less than 2 per cent, passes a 50-mesh sieve; and that not more than 6 per cent passes a 100-mesh sieve.

The quality of the sand used in concrete, is as important as the quality of the cement. Failure to recognize this fact has produced many disastrous results.

2. Fine aggregate shall always be tested. It shall be of such quality that mortar composed of one part Portland cement and three parts fine aggregate by weight, when made into briquettes shall show a tensile strength at least equal to the strength of 1:3 mortar of the same consistency made with the same cement and standard Ottawa sand, and shall show a tensile strength of at least 180 lbs. per square inch at the age of 7 days. If the aggregate be of poorer quality, the proportion of cement should be increased to secure the desired strength.

NOTE.—Standard Ottawa sand is a natural sand obtained at Ottawa, Illinois, which is prepared and sold by the Ottawa Silica Company under the direction of the Special Committee on Uniform Tests of Cement of the American Society of Civil Engineers. It is graded in size to pass a screen having 20 meshes, and be retained on a screen having 30 meshes per linear inch.

SECTION 123. QUALITY OF COARSE AGGREGATE.—1. Coarse aggregate shall consist of crushed stone or gravel which is retained on a screen having ¼ inch diameter holes, and shall be graded in size from small to large particles. The maximum size shall be such that all the aggregate will pass through a 1¼ inch diameter ring. The particles shall be clean, hard, durable, and free from all deleterious material.

Aggregates for fireproofing, Sec. 164.

2. Gravel shall be free from clay or loam except such as naturally adheres to the particles. If clay or loam is in such quantities that it cannot be readily removed by dipping in water or brushing lightly with the hand, the gravel shall be washed. When bank-run gravel is used, it should be screened from the sand and remixed in the proper proportion for fine and coarse aggregate.

NOTE.—It is strongly recommended that all gravel used for reinforced concrete be thoroughly washed. Attention is also called to the fact that pure quartz gravel is not as good a fire-resisting aggregate as trap; also that limestone or dolomite is likely to calcine and granite to spall when exposed to high heat. Conglomerates consisting essentially of coarse grained sandstones make good concrete, but slate and shale give poor results as a rule.

SECTION 124. QUALITY OF REINFORCEMENT.—All steel used in reinforced concrete shall meet the requirements of the current Standard Specifications for Billet-Steel Concrete Reinforcement Bars of the American Society for Testing Materials. No reinforcement produced from re-rolled rails or second-hand materials shall be used in any structure without the written permission of the Superintendent. If such reinforcement be permitted, it shall meet the requirements of the current Standard Specifications for Rail-Steel Concrete Reinforcement Bars of the American Society for Testing Materials. Cold drawn steel wire made from open hearth billets of the grade of rivet steel or from Bessemer billets, may be used in floor and roof slabs, column hooping, and reinforcement for temperature and shrinkage stresses. It shall have an ultimate strength of not less than 85,000 lbs. per square inch and test specimens shall bend 180 degrees around their own diameter without fracture.

Factors Controlling Design

SECTION 125. ALLOWABLE UNIT WORKING STRESSES.—In the design of reinforced concrete structures when the concrete is mixed in the proportions of 1:2:4, and satisfies the strength requirements of Section 120, the following working stresses for concrete and steel shall be used:

	Lbs. per Sq. in.
Extreme fibre stress on concrete in compression	650
Concrete in direct compression	500
Shearing stress in concrete when diagonal tension is not resisted by steel	40
Shearing stress in concrete when web reinforcement is proportioned to resist two-thirds of the external vertical shear	120
Bond stress between concrete and plain reinforcing bars	80
Bond stress between concrete and deformed bars	100
Tensile stress in steel reinforcement	16,000

Bearing on a concrete surface having a total area at least three times the area of the loaded portion, may be taken at 37½ per cent of the ultimate strength of the concrete, when all other stresses are properly provided for.

Compressive stress in steel as specified in Sections 142, 143 and 144, or in the ratio of the moduli of elasticity of steel to concrete.

In continuous beams the extreme fibre stress in concrete in compression may be increased 15 per cent adjacent to the supports.

In proportioning the section of concrete for shearing stresses, the effective depth from center of compression area to center of steel shall be used.

Stresses in concrete mixed in the proportions of 1:1½:3 in accordance with Section 120 may be increased 20 per cent in excess of the above stresses.

Working stresses on concrete in walls, Sec. 147.

Working stress on cinder concrete, Sec. 167, par. 5.

Other working stresses on concrete, Sec. 65, par. 3.

SECTION 126. GENERAL ASSUMPTIONS.—As a basis for calculating the strength of beams and slabs, the following assumptions shall be made:

(a) A plane section before bending remains plane after bending.

(b) The modulus of elasticity of concrete in compression remains constant within limits of working stresses fixed in this Code.

(c) The adhesion between concrete and reinforcement is perfect.

(d) Concrete has no value in resistance to tension.

(e) Initial stress in the reinforcement due to contraction or expansion in the concrete is negligible.

(f) The ratio of the moduli of elasticity of 1:2:4 stone or gravel concrete and steel inflexure shall be taken as 1:15.

(g) The ratio of the moduli of elasticity of 1:1½:3 stone or gravel concrete and steel inflexure shall be taken as 1:12.

The span length for beams and slabs shall be taken as the distance from center to center of supports, but need not be taken to exceed the clear span plus the over-all depth of beam or slab. Brackets shall not be considered as reducing the clear span in the sense here intended.

Weight of concrete, Sec. 63.

Bending Moments of Uniformly Loaded Floor and Roof Slabs

SECTION 127. BENDING MOMENTS OF SLABS SUPPORTED ON TWO SIDES.—The bending moments of slabs due to uniformly distributed loads shall be taken as not less than:

⅛ WL, at center when simply supported.

1/10 WL, at center and continuous support when supported at one end and continuous at the other.

1/12 WL, at center and intermediate supports when continuous over more than two supports.

W = Total distributed dead and live loads.

L = Length of span.

SECTION 128. BENDING MOMENTS OF SLABS SUPPORTED ON FOUR SIDES.—The bending moments of uniformly loaded slabs supported on four sides and reinforced in both directions shall be taken as:

⅛ WL, at center in each direction when simply supported.

1/10 WL, at center and continuous support when continuous over one support.

1/12 WL, at both center and supports when continuous over two or more supports.

SECTION 129. DISTRIBUTION OF LOADS.—The distribution of loads on square and rectangular slabs supported on four sides, shall be determined by the following formula:

$$r = \frac{l^4}{l^4 + b^4}$$

in which r = the proportion of the load supported by the transverse reinforcement.

l = length of slab.

b = breadth of slab.

If the length of the slab exceeds 1½ times its width, the transverse reinforcement shall be designed to carry the entire load.

Bending Moments of Uniformly Loaded Beams and Girders

SECTION 130. TERM BEAM DEFINED.—The term beam as used in this section shall be understood to include the term girder, unless specific distinction be made.

SECTION 131. BEAMS WITH SIMPLE OR CONTINUOUS SUPPORTS.—The bending moments of uniformly loaded beams shall be taken as:

⅛ WL, at center when simply supported.

1/10 WL, at center and over continuous support when supported at one end and continuous at the other.

1/12 WL, at both center and supports when continuous over more than two supports.

SECTION 132. BEAMS SUPPORTING RECTANGULAR SLABS.—1. Beams supporting rectangular slabs reinforced in both directions, shall be assumed to take the proportions of load as determined by the formula in Section 129.

2. The bending moments of slabs, beams or girders which are continuous for two spans only, shall be taken as ⅛ WL over the central support and 1/10 WL near the middle of the span.

General Design Requirements for Beam and Slab Construction

SECTION 133. SPECIAL MEMBERS.—The bending moments for slabs or beams with spans of unusual length or due to other than uniformly distributed loads, shall be more exactly computed according to accepted theory.

SECTION 134. CONTINUOUS FLOOR CONSTRUCTION.—In continuous slabs, beams or girders, full provision shall be made for the negative bending moments over the supports by placing sufficient negative reinforcement near the top of the members to resist the stress. This reinforcement shall pass beyond the point of inflection in beams or girders and be anchored in the compression concrete of the member a sufficient distance to develop the full strength of the steel through bond stress. The critical section of continuous construction is over the support.

NOTE.—It is not considered best practice to design a beam as simply supported, with a bending moment of ⅛ WL at the center, and to provide an arbitrary amount of reinforcement over the support, such as one-half of that at the center.

SECTION 135. WEB REINFORCEMENT IN BEAMS.—1. Members of web reinforcement in beams shall be designed for diagonal tensile stresses, using the calculated vertical shearing stress as a measure of these tensile stresses. They shall not be spaced to exceed three-fourths of the depth of the beam in that portion where the web stresses exceed the allowable value of the concrete in shear. It shall be assumed that two-thirds of the external vertical shear is provided for by the steel in calculating the stresses in stirrups, diagonal web members, and bent up bars; and the remaining one-third of the shear shall be assumed as taken by the concrete, in accordance with Section 125.

2. Web members such as stirrups, when not rigidly attached to the longitudinal steel at both top and bottom, shall be carried around and bent over the longitudinal members or otherwise sufficiently anchored in the compression concrete to develop the tensile stresses existing in them. Diagonal members shall be rigidly attached to the longitudinal steel on the tension side. Stirrups at the ends of continuous girders shall be inverted with the free ends anchored in the compression concrete at the bottom of the beam. The length of stirrups or diagonals embedded in compression concrete shall be sufficient to develop their entire tensile stresses by adhesion.

SECTION 136. T BEAMS.—1. Where adequate bond is provided at junction between slab and beam, and the two are cast at the same time as a unit, the slab may be considered as an integral part of the beam, provided its effective width shall not exceed on either side of the beam one-sixth of the span length of the beam, nor be greater than four times the thickness of the slab on either side of the beam; the measurements being taken from line of intersection between slab and beam.

2. In beams with T sections the width of the stem only shall be used in calculating longitudinal shear and diagonal tension. An effective bond shall be provided at the junction of the beam and slab when the principal slab

reinforcement is parallel to the beam, by the use of transverse reinforcement extending over the beam and well into the slab.

3. In the design of T beams acting as continuous beams, sufficient compression area shall be provided on the under side at the support, either by the use of properly designed brackets or by embedding additional compression steel in the concrete extending to the point of inflection.

SECTION 137. MINIMUM THICKNESS OF SLABS.—The minimum thickness of concrete floor slabs shall be 4 inches, and for roof slabs 3½ inches.

SECTION 138. FLOOR FINISH.—Cement or concrete floor finish shall not be considered in calculating the strength of floor members unless it be laid at the same time they are cast.

SECTION 139. COMPOSITE FLOORS.—The design of composite floors consisting of rows of hard-burned terra cotta tile, concrete blocks, sheet steel, or other approved fire resistive material, separated by ribs or beams of reinforced stone or gravel concrete, shall conform to all the provisions of this Part so far as they are applicable. The ribs shall be at least 5 inches wide. The tile or blocks shall be regarded only as fillers, and shall not be considered in the design except as dead load. If designed as a T-beam, the slab portion above the fillers shall be at least 2½ inches thick, and shall consist of the same mixture used for the ribs, and shall be cast at the same time; under these conditions it may be considered in the design of the ribs. Tile or concrete block fillers shall be laid with Portland cement mortar joints, and shall be thoroughly wet before the concrete is poured. The protection for steel bars in bottom of ribs shall be the same as for other beams.

To resist expansion stresses, reinforcement bars not less than ½ inch diameter, shall be placed in the concrete at right angles to the ribs and above the fillers, at intervals not exceeding 30 inches.

Design of Columns and Walls

SECTION 140. LENGTH OF COLUMNS.—The length of columns shall be taken as the maximum unsupported length.

The unsupported length of columns shall not exceed fifteen times the least side or diameter, and in no case shall the least side or diameter be less than 12 inches. The length shall include any corbel or knee brace attached to the column.

SECTION 141. COLUMNS WITHOUT HOOPS.—Axial compression in reinforced concrete columns without hoops, bands, or spirals, containing not less than ½ per cent, nor more than 3 per cent of vertical reinforcement, secured against lateral displacement by steel ties placed not farther apart than fifteen diameters of the vertical rods, nor more than 12 inches, shall not exceed 500 pounds per square inch on the effective area of the concrete, plus 6,000 pounds per square inch on the vertical reinforcement. The percentage of reinforcement shall be calculated upon the effective area of the column, which is the area within the reinforcement. Steel ties shall be not less than ¼ inch in diameter or least dimension. At least four vertical bars shall be used in every reinforced column, and no bar shall have an area of less than ¼ square inch.

NOTE.—Round reinforced concrete columns are better adapted to resist fire than square ones. The latter spall badly at the corners, due to unequal expansion, when attacked by intense heat. A round column or one approximating that shape should be used wherever liable to be subjected to fire. Some authorities advocate the encasing of concrete columns by a protective covering of some material to prevent spalling. Round concrete columns protected by only an inch of plaster on metal lath, are known to have resisted an intense fire excellently; this indicates that even such protection is worthy of careful consideration. In such construction the metal lath should be held securely in place by metal clips anchored into the concrete. Wrapping the lath with wire is not sufficient.

Strength test requirements for concrete and steel, Secs. 120 and 124.

SECTION 142. COLUMNS WITH HOOPS.—Axial compression in reinforced concrete columns with not less than 1 per cent of hoops or spirals (that is, a volume of steel equal to 1 per cent of the volume of concrete within the hoops or spirals for a unit length of column) spaced not farther apart than one-sixth of the diameter of enclosed column, but in no case more than 3 inches, with not less than one nor more than 4 per cent of vertical reinforcement, shall not exceed 750 pounds per square inch on the effective area of the concrete, plus 9,000 pounds per square inch on the vertical reinforcement. The hoops or spirals shall be uniformly spaced, and shall be rigidly attached to at least four vertical bars in each convolution.

Columns required to be settled before being built upon, Sec. 157, par. 2.

SECTION 143. STRUCTURAL STEEL AND CONCRETE COLUMNS.—Axial compression in structural steel columns thoroughly encased in concrete having a minimum thickness of 4 inches and reinforced with not less than 1 per cent of steel (that is, a volume of steel equal to 1 per cent of the volume of concrete within the hoops) equally divided between vertical reinforcement and hoops or spirals spaced not more than 12 inches apart, may be taken at 16,000 pounds per square inch on the net section of the structural steel, no allowance being made for the concrete casing. The hoops or spirals shall be placed not nearer than 1 inch from the structural steel, or nearer than 1½ inches from the outer surface of the concrete. The ratio of length to least radius of gyration of the structural steel section shall not exceed 120.

Working stresses for structural steel, Sec. 65.

SECTION 144. COLUMNS CONSTRUCTED WITH SPECIAL CONCRETE.—In reinforced concrete columns the compression on the concrete may be increased 20 per cent when the fine and coarse aggregates are carefully selected, and the proportion of cement to total aggregates increased to one part of cement to not more than four and one-half parts of aggregate, fine and coarse, either in proportion of one part of cement, one and one-half parts of sand and three parts of stone or gravel, or in such proportions as will secure the maximum density. The unit stress on the vertical reinforcement in such columns shall not exceed twelve times the unit stress on the concrete.

SECTION 145. COLUMNS ECCENTRICALLY LOADED.—Bending stresses in columns due to eccentric loads, shall be provided for by increasing the section of concrete or steel so that the total unit stress shall not exceed the allowable working stress in flexure.

SECTION 146. STEEL BASE PLATES.—Suitable steel base plates or castings shall be provided at the bottom of columns to distribute the loads over the footings, and the vertical reinforcement bars shall bear squarely on these plates, or the reinforcing bars shall be carried down into an enlarged footing to distribute the load through bond stress.

SECTION 147. WALLS.—Exterior and interior bearing and non-bearing walls of reinforced concrete shall be securely anchored to all intersecting walls, columns, and floors, and the allowable compressive stress shall not exceed 250 pounds per square inch. The thickness shall be not less than two-thirds that specified for brick walls, and in no case less than 8 inches. All such walls shall be reinforced with steel running both horizontally and vertically. The amount of reinforcement shall be not less than 1/5 of 1 per cent of the cross-section of the wall, and shall be equally disposed near each face of the wall; except that in walls or partitions 8 inches or less in thickness, the reinforcement may be placed as a single layer in the middle. Reinforcement shall not be spaced more than 18 inches apart. Additional reinforcement shall be placed around wall openings, and all vertical and horizontal reinforcement shall be wired or have other mechanical bond at intervals not exceeding 18 inches in either direction.

Reinforced concrete partitions, Secs. 90 and 115.

General Provisions for Design of Girderless Floors or Flat Slabs

SECTION 148. GIRDERLESS FLOORS.—1. Girderless floors or flat slabs consisting of reinforced concrete slabs resting upon columns with flaring heads, with or without drop heads or column caps, and in which no beams or girders are used, except around openings in the floor or along walls, shall be designed in accordance with the bending moment coefficients and stresses specified in this Code. No empirical formulas based on the results of tests shall be permitted, but the design shall in general be based upon the principles of continuous or cantilever construction as herein indicated.

2. The methods of analysis shall be as follows:

(a) The portion of the slab adjacent to the column shall be considered as a circular plate supported at the center forming the cantilever portion. The remainder of the slab shall be considered as a simply supported portion suspended from the cantilever plates. The cantilever portion shall be designed for a uniform load over its area equal to the live and dead load on that area plus a concentrated load on its perimeter equal to the floor load resting on the suspended portion of the slab. The radius of the cantilever plate shall be the average distance from the center of the column to the points of inflection of the slab.

(b) Or the slab may be considered as consisting of a series of continuous broad, flat, girders reinforced with bands of steel consisting of rods supported at the top of the slab over the columns and depressed to the bottom of the slab at the center of the span. These bands of reinforcement may be arranged to run in two directions directly from column center to column center; or in four directions, the former bands being combined with reinforcement running diagonally from column to column.

SECTION 149. COLUMNS FOR GIRDERLESS FLOORS.—1. The column capital shall have a diameter or least side at the top in no case less than 0.225 L where L is the length of side of the square equivalent to the area of the rectangle included between four adjacent columns. The thickness of the column capital at this diameter shall be not less than 1¼ inches. The slope of the column capital shall nowhere exceed an angle of 45 degrees with the vertical.

2. A depressed head or "drop" may be cast above the column capital and the dimensions of this cap shall be not less than 0.4 of the side of the equivalent square panel.

3. The point of inflection shall be assumed $1/6 \sqrt{3}L$ from the center of the column.

4. The width of bands shall be such as to properly cover the panel area, but shall not be wider than 0.4 times the side of the square panel. Where steel is provided in two directions only, the central portion of the panel shall be considered as a slab supported on four sides.

5. Punching shear shall be calculated at the edge of the column shaft and shall not exceed 120 lbs. per sq. inch. In computing shearing stress for

the purpose of determining resistance to diagonal tension, a point shall be taken at a distance out from the column capital equal to the effective depth of the slab.

6. Working stresses and coefficients shall in general comply with Sections 125, and 127 to 132, inclusive, of this Code. In rectangular panels, the long dimension shall not be more than four thirds times the short dimension. Interior columns shall be capable of resisting the unbalanced bending moment produced by a panel with live load adjacent to a panel without live load. Floor slabs at walls shall be considered as simply supported on walls or wall beams. If the proportion of the slab adjacent to a wall column is assumed as a cantilever, the wall column or pier shall be capable of resisting the unbalanced moment produced by such cantilever. Bars for negative bending moment shall extend at least to the quarter point of the span, and if the bars have a greater diameter than ¾ inch, special attention shall be given to bond and anchorage.

Requirements for Reinforcement

SECTION 150. EXTERNAL AND INTERNAL DEFECTS.—All reinforcement shall be free from excessive rust, scale, grease, paint or any coating which would tend to reduce or destroy the bond between the steel and the concrete. Bars shall also be free from injurious seams, slivers, flaws, and other mill defects. The weight of any lot of bars shall not vary more than 5 per cent from the standard weight of the lot as given by manufacturers' handbooks.

SECTION 151. PLACING AND SPACING OF REINFORCEMENT.—All reinforcement shall be accurately located and mechanically secured against displacement during the placing of the concrete. Reinforcement bars for slabs shall not be spaced farther apart than two and one-half times the thickness of the slab. The spacing of parallel bars in beams shall be not less than three diameters from center to center, nor less than one inch. The clear spacing between two layers of bars shall be not less than one inch. In restrained or cantilever construction reinforcement shall extend beyond the supports into adjacent construction for full and effective anchorage, except that when this is not practicable, anchorage shall be obtained by other means acceptable to the Superintendent. Special reinforcement shall be provided to resist concentrated loads. Slabs reinforced in one direction only, shall have shrinkage rods not less than ¼ inch in diameter placed above the reinforcement and spaced not over 2 feet apart. All reinforcement shall be assembled well in advance of the placing of the concrete, and shall be inspected and approved by the Superintendent before concrete is deposited.

SECTION 152. PROTECTION FOR REINFORCEMENT.—Steel reinforcement shall have a minimum protection of concrete on all sides as follows:

In columns and girders, 2 inches; in beams and walls, 1½ inches; and in floor slabs, 1 inch.

The steel in footings for walls and columns shall have a minimum protection of 4 inches of concrete.

SECTION 153. SPLICES IN REINFORCEMENT.—Splices in reinforcing bars shall be designed to transfer the calculated stress at the joint either by bond and shear through the concrete, or by bearing between the steel. Splices at points of maximum stress shall be avoided where possible. Lap splices of bars shall be of sufficient length to develop the required stress in the joint without exceeding the bond stress permitted. In columns where necessary to splice vertical bars having areas in excess of 1¼ sq. inches, it shall be done by cutting the bars squarely at the ends and enclosing them in a close-fitting pipe sleeve, or uniting them by a threaded splice or other mechanical connection that will transfer the load from one to the other without stressing the adjoining concrete excessively. The middle point of such splices shall be within one foot above the floor level. Splices in column hooping where necessary, shall be sufficient to develop the full strength of the hooping.

Workmanship for Concrete

SECTION 154. MIXING.—1. The separate ingredients of concrete shall be accurately measured, and thoroughly mixed in a manner to produce a homogeneous mass of uniform color and of such a viscous consistency that it will flow to all parts of the forms without separation of the coarse aggregate from the mortar.

NOTE.—It is usual practice to consider a bag of Portland cement weighing not less than 94 lbs., as equivalent to one cubic foot.

2. Except when limited quantities are required, or when the conditions of the work make hand mixing preferable, mixing shall be done in a mechanical batch mixer from which a complete batch shall be discharged before another is received. All ingredients shall be mixed together for at least one minute, the mixer making at least 20 revolutions. The speed of the mixer shall not exceed 20 revolutions per minute. In all cases, the mixing shall be continued until the consistency is constant.

SECTION 155. DEPOSITING.—1. Concrete shall be deposited, thoroughly tamped and worked to place before initial set begins, and shall then be kept free from shocks and disturbances of every kind until it has fully hardened. Retempering of concrete after its initial set shall be prohibited.

2. When the work of placing concrete is suspended, all necessary grooves for joining future work shall be made before the concrete sets.

3. Before depositing new concrete upon concrete already set, the contact surfaces shall be roughened, cleaned of all laitance and loose material, and then drenched with water and slushed with a grout consisting of one part Portland cement and not more than two parts fine aggregate immediately before placing the fresh concrete. If a watertight joint is desired, or if granolithic is to be deposited on old concrete, it is necessary that a neat cement grout be used.

SECTION 156. DRYING AND FREEZING.—1. When fresh concrete is exposed to rapid drying conditions, precautions shall be taken to keep it moist for a period of at least seven days after being deposited. Where practical this shall be done by a covering of wet sand, burlap or some other equally effective method. Thorough wetting twice a day is recommended.

2. In freezing weather all materials used in making concrete, particularly the coarse aggregate, shall be heated, and precautions shall be taken to prevent the concrete freezing while being deposited; and thereafter it shall be kept above 40 degrees until the concrete has obtained its final set, but such period shall be not less than 72 hours.

SECTION 157. JOINTS.—1. Construction joints shall be avoided wherever practicable, but when they are necessary they shall be located at such sections as will least affect the structural strength and shall be made at right angles to the direction of principal compressive stress. In members of floor systems, joints shall be made within the middle third of the span where practicable. In columns, joints shall only be permitted at the bottom face of the lowest connecting floor members. Temperature changes and shrinkage during setting necessitate joints in independent walls at intervals of 50 to 80 feet when not otherwise provided for by effective reinforcement.

NOTE.—To provide for stresses due to contraction in setting and atmospheric temperature changes in long reinforced concrete buildings, it is customary to construct expansion joints across the buildings at intervals of about 200 feet.

2. Girders, beams, and slabs shall not be cast upon freshly formed columns until a period of 4 to 6 hours have elapsed to permit settlement.

SECTION 158. CONSTRUCTION OF FORMS.—1. Forms shall be substantial and unyielding, and care shall be exercised to make them as nearly water-tight as practicable.

2. Care shall be taken to insure that all debris is removed from forms, and that they are thoroughly greased or wetted before concrete is deposited in them. Beam forms shall be so designed that at least one side may be removed without disturbing the bottom portion of the forms and its supports; and column forms, so that they may be removed without disturbing beam and slab forms. Cleanout holes shall be provided in the bottom of column forms where necessary to insure the removal of wood chips or other debris.

NOTE.—It is considered good practice to give a slight camber to forms for beams and girders to overcome the effects of the unavoidable settlement.

SECTION 159. REMOVAL OF FORMS.—1. The time for the removal of forms shall always be subject to approval by the Superintendent.

NOTE.—It is recommended that forms shall in no case be removed in less time than fixed in the following schedule, except by written permit from the Superintendent. This schedule presupposes that the concrete has been deposited while the outside temperature was above 40° Fahr., with a rising temperature, and that ample supports are left to carry the construction and any superimposed loads.

Schedule

Bottom of slabs, spans of 6 feet	4 days
Plus 1 day extra for each additional foot of span.	
Bottom of beams and girders of ordinary length	14 days
Beams of span of 20 feet	21 days
Sides of lintels, girders and beams	3 days
Columns	3 days
Thin walls	3 days

2. Girders of 25-foot span or over shall be considered as special cases and shall be subject to the inspection of the Superintendent before removal of the supports.

3. Composite floors, same as for ordinary beams.

4. All reinforced concrete shall be carefully inspected to insure its soundness and reliability before main supports are removed.

5. No loads shall be placed upon a reinforced concrete floor before the removal of the form supports, which would in any way tend to overstress such supports or those below.

6. Special care shall be observed in removing forms when the concreting has been done in cold weather. Concrete which has frozen accidentally before setting, shall be thawed and kept thawed until it is determined whether the cement will set. In this case, sufficient water shall be provided for the cement to hydrate during this action.

NOTE.—A special permit should be obtained for removal of forms from concrete deposited when the outside temperature was below 32° Fahr.; and the number of days required should be increased in proportion to the amount of time the temperature remained below 32° Fahr. after the concrete was deposited.

SECTION 161. INSPECTION.—Every reinforced concrete building shall be erected under the constant supervision of a reputable and competent inspector furnished by the owner or architect, and acceptable to the Superintendent. It shall be the duty of the inspector to keep a daily record of the work done, to observe whether the materials employed, and the methods of construction are in all respects in accord with the specifications filed with the Superintendent, and the requirements of this Code; and to make record of all variations therefrom. A copy of these daily reports shall be filed with the Superintendent, who is empowered to stop any improper construction until its faults are corrected, or to cause the removal of any defective work which he may consider dangerous.

A set of plans shall be on file at the building upon which the Superintendent shall mark in ink the progress of the work, and state the time and dates on which concrete for each portion of the structure was deposited; and the Superintendent shall indicate thereon the date upon which the forms may be removed. Record shall also be made of the date upon which forms were actually removed.

NOTE.—For theory of design and allowable practice in reinforced concrete construction, see Report of the Joint Committee on Concrete and Reinforced Concrete, as published by the American Society for Testing Materials.

Reinforced Concrete for Fireproofing

SECTION 162. APPROVED CONSTRUCTION.—1. Concrete is approved for all fire-resistive construction, also for the protection of steel structural members, or for any other fire-proofing purposes in any building.

2. Any system of reinforced concrete construction may be approved for the construction of floor or roof panels, or partitions in skeleton frame or any other type of fire-resistive building, provided that the unit stresses in the materials do not exceed those specified in this Code as permissible for use in such design; and that the concrete and the construction conform to the various other requirements herein specified for such use, including the fire test.

SECTION 163. MIXTURE.—Concrete for fireproofing purposes shall consist of a mixture of viscous consistency of one part Portland cement to not more than seven parts of fine and coarse aggregate by volume. The aggregate shall be mixed in the ratio of two parts of fine to not more than five parts of coarse, or in such proportions as will give the densest mixture.

NOTE.—A mixture of 1:2:4 is recommended as giving very satisfactory results. It is particularly advantageous for floor and roof slabs by reason of its density and consequent increase in waterproofness, as well as strength.

SECTION 164. AGGREGATES.—Fine aggregates shall be of quality described in Section 122.

Coarse aggregates shall consist of gravel, crushed stone, hard burned brick, terra cotta, slag, or steam boiler cinders, and shall be clean, hard, and free from deleterious material. All aggregates shall be sized to pass a 1 inch screen and be retained upon a ¼ inch screen, and shall be reasonably dry when screened.

SECTION 165. MANIPULATION.—Concrete for fireproofing shall be mixed, deposited, and protected in accordance with the requirements of Sections 154 to 159, inclusive, of this Code.

SECTION 166. REINFORCEMENT.—1. The steel reinforcement in concrete used for fireproofing, shall be of quality required by Section 124, and the installation shall be in accordance with the specifications of Section 151. The longitudinal members in mesh reinforcement shall not be spaced more than 4 inches center to center, and the least dimension of mesh opening shall be 2 inches. Mesh metal fabrics of all kinds shall have a side lap of not less than 3 inches.

2. All reinforcement essential to secure the required strength of arches or slabs, shall be fully embedded in the concrete, and shall have a protection of at least 1 inch of concrete on the under side.

3. Exposed metal centering or exposed metal of any kind shall not be con-

sidered a factor in the strength of any part of any concrete construction subject to fire; and a plaster finish applied over the metal shall not be accepted as sufficient protection.

SECTION 167. CINDER CONCRETE.—1. Cinder concrete may be used constructively as fireproofing, only for floors and roofs between steel beams, and for interior non-bearing walls or partitions.

2. Cinders shall be composed of hard, well burned, vitreous clinker, free from sulphides, fine ashes and foreign matter. The use of gas-house, or locomotive cinders, or stove or heating furnace ashes, is prohibited.

3. In the selection of cinders for concrete, care shall be exercised to insure that they carry only a small percentage of unburned coal or coke. The amount shall not exceed 15 per cent.

NOTE.—Attention is called to the fact that a properly proportioned concrete made from carefully selected cinders is a most excellent fire-resistive material; but the use of inferior cinders or an improper mixture, that is, one which is too lean or too dry, may be productive of danger, due either to weakness, or liability to produce corrosion of metal in contact with the concrete.

Unburned coal and coke in cinders serve to introduce sulphur into the concrete, which is likely to corrode metal embedded in it unless the concrete is sufficiently wet and rich enough to furnish a coating of cement on the metal. Sulphides will also tend to deteriorate the concrete under conditions of oxidation.

Soft coal cinders should be used with the utmost caution. Satisfactory concrete can be made from clean, thoroughly calcined, soft coal clinker; but soft coal is very liable to carry with it considerable free sulphide of iron (iron pyrites), and cinders from such coal are almost sure to contain an excess of sulphides, which are fatal to good concrete.

4. Cinder concrete in the proportions of 1:2:5 to qualify for use for fireproofing, except when used as fill above the floor arch proper, shall develop an average crushing strength of not less than 800 pounds per sq. inch at 28 days, when tested in accordance with the method of test prescribed for stone concrete in Section 120.

5. The allowable extreme fibre stress in compression in cinder concrete slabs between steel beams shall not exceed 300 pounds per sq. inch. The ratio of the moduli of elasticity of 1:2:5 cinder concrete and steel shall be taken as 1 to 30.

NOTE.—Cinder concrete is very porous, and while this property adds to its fire-resisting qualities, it is a serious defect as regards resistance to water. See Note, Section 110, paragraph 3.

Weight of cinder concrete and fill, Sec. 63.

SECTION 169. FLOOR SYSTEMS APPROVED ON DESIGN.—1. Segmental concrete arches or flat slabs shall be approved for fireproofing if designed and constructed in accordance with the requirements of Parts XXII and XXIII in so far as they are applicable; but the permissible stresses for cinder concrete shall be taken as specified in Section 167.

2. The span of concrete arches or slabs for fireproofing, shall be taken as the distance center to center of the supporting steel beams, and shall not exceed 8 feet unless the coarse aggregate in the concrete be either stone or gravel, in which case the span shall be limited by the design.

NOTE.—When the span of cinder concrete floor slabs exceeds 6 feet, special care should be exercised in inspecting the details of construction, and the removal of forms.

3. The minimum thickness of arches or slabs of cinder concrete for floor and roof construction, shall be 3½ inches, and in no case less than one eighteenth of the span length between supporting beams.

SECTION 171. TIE RODS.—1. Segmental arches shall have a rise of not less than ¾ inch per foot of span, and steel tie rods of proper size, spacing, and location to resist the thrust shall be used. The rods shall be protected as required in Section 111, paragraph 2.

2. In flat arches, if tie rods are omitted, the reinforcement shall be continuous, or the ends of the bars shall be hooked over the beams or otherwise securely fastened to them at intervals not exceeding 3 feet.

SECTION 172. CONCRETE FILL.—Concrete for fill shall consist of one part cement and not more than ten parts of aggregate. Aggregates shall be as specified in Section 164. All concrete fill shall be well mixed, thoroughly wet, tamped to place, and brought to a level at the required height. See Section 110, paragraph 2.

Chimneys, Flues and Heating Apparatus

SECTION 178. CHIMNEYS, SMOKE FLUES, GAS FLUES AND FIREPLACES.—1. All chimneys hereafter erected shall be of brick or stone laid in Portland cement mortar without addition of lime, reinforced concrete or other approved incombustible material, extending at least 3 feet above the point of contact with a flat roof or 2 feet above the ridge of a pitch roof, and shall be properly capped with terra cotta, stone, cast iron, or other approved incombustible weatherproof material.

NOTE.—Portland cement mortar is very superior to lime mortar in resisting the action of heat and flue gases. The latter disintegrates in time, and is liable to fall out of the joints, thus producing a hole through which a fire is likely to originate.

2. The brickwork or reinforced concrete of the smoke flues of all boilers, furnaces, baker's ovens, large cooking ranges, large laundry stoves, and all flues used for a similar purpose shall be at least 8 inches in thickness. Walls of smoke flues used exclusively for ordinary stoves or open fireplaces shall be not less than 4 inches thick. Brick set on edge shall not be permitted in chimney construction.

3. Where two or more smoke flues are contained in the same chimney, the walls between the several flues shall be not less than 4 inches thick. The walls of stone smoke flues shall be 4 inches thicker than required for brick or reinforced concrete. No smoke flue shall have smoke pipe connections in more than one story of a building.

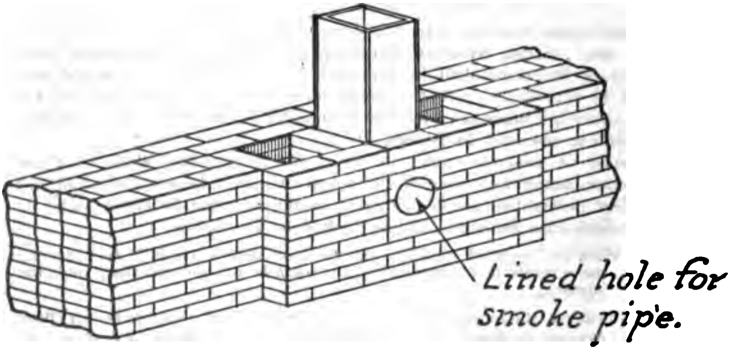

FIG. 29.—Indicates method of building in flue tile during construction of chimney

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4. Every smoke flue contained in a chimney hereafter erected shall have an area of at least 64 square inches and, unless required to be lined with fire brick, shall be lined with hard burned terra cotta or fire clay flue lining made smooth on the inside. The flue lining shall start from the bottom of the flue, or from the throat of the fireplace if the flue starts from a fireplace, and shall be carried up continuously the entire height of the flue. If the thickness of the masonry surrounding the throat be less than 8 inches in any part, the lining shall start at bottom of the lintel. The ends of the sections of all such lining tile shall be laid in cement mortar and the tile shall be built in as the flues are carried up. Fig. 29.

No parging mortar nor plaster shall be used on the inside of any fireplace, chimney, or flue.

NOTE.—While walls 4 inches thick and lined are permitted for chimneys serving as flues where high temperatures are not maintained, a minimum wall thickness of 8 inches is strongly recommended, especially in localities subject to long, severe winters, and continuous hot fires are a necessity.

5. In every building, where one or more smoke flues start from the cellar or lowest story, at least one such smoke flue shall have an internal cross-sectional area of at least 96 square inches and shall start at least 3 feet below the ceiling.

6. In no case shall a chimney be corbeled more than 8 inches from the wall, and such corbeling shall consist of at least five courses of brick. Piers which support chimneys shall start from the foundation on the same line with the chimney breast. They shall be not less than 12 inches on the face and shall be properly bonded into the walls. No chimney shall rest upon, nor be carried by woodwork. No combustible furring or sheathing shall be placed against any smoke flue or chimney breast.

7. The walls of flues used only for gas burning appliances shall be of brick or concrete at least 4 inches thick and lined as required in paragraph 4 of this section. Where two or more such flues are contained in the same chimney, the walls between the several flues shall be not less than two thicknesses of the tile lining with joints broken, except that at least every third partition shall be not less than 4 inches thick of brick or its equivalent, and bonded into the walls. Not more than one appliance or utensil in which gas is used as fuel shall be connected to a single flue, nor shall any such appliance or utensil be connected to any flue to which a smoke pipe is connected.

8. The smoke flue of every high pressure steam boiler and every appliance producing a corresponding temperature in the smoke flue shall, if built of brick, stone, reinforced concrete or other approved masonry, be lined on all sides with not less than 4 inches of fire brick laid in fire mortar for a distance of at least 25 feet from the point where the smoke connection of the boiler enters the flue.

9. Interior vertical smoke stacks or flues for steam boilers or other furnaces, and similar heating devices producing a corresponding temperature, may be of metal not less than No. 10 U. S. gauge, properly riveted, jointed, and braced at intervals of at least 20 feet. Such stacks shall either be enclosed by approved masonry walls not less than 8 inches thick with an air space of at least 4 inches between lining and wall; or if such stacks or flues are not enclosed with masonry they shall have a clearance from all combustible material of not less than one-half the diameter of the stack, but not less than 24 inches, unless the combustible material be properly guarded by loose fitting metal shields, in which case the distance shall be not less than 12 inches. Where such a stack passes through a wooden framed roof, it shall be guarded by a galvanized iron ventilating thimble extending from at least

9 inches below the underside of the ceiling or roof beams to at least 9 inches above the roof, and the ventilating thimble shall have a clearance of not less than 18 inches, except that for stacks for low grade furnaces such as hot air, hot water, and low pressure steam heating furnaces, coffee roasting ovens, candy furnaces, etc., the clearance may be reduced to 12 inches. Metal smoke stacks shall not be permitted to pass through floors. Smoke flues shall not be permitted inside of vent flues for ranges.

10. Exterior metal smoke flues for boilers, large cooking ranges, and similar heating devices, shall be of approved construction and supported on approved masonry foundations, and shall have a clearance of at least 4 inches from the outside wall. Such flues having an area not exceeding 255 square inches shall be constructed of not less than No. 16 U. S. gauge metal; if the area exceeds 255 square inches the thickness of the metal shall be not less than No. 10 U. S. gauge.

11. The smoke flue of every smelting furnace and of every other similar device which heats the flue to an extremely high temperature, shall be built with double walls of thickness suitable for the temperature. There shall be an air space between the walls, and the inside wall shall be of firebrick not less than 4 inches thick.

12. Chimneys of cupola-furnaces, blast-furnaces, and similar devices, shall extend at least 10 feet above the highest point of any roof within a radius of 50 feet, and no woodwork shall be within 3 feet of any part of any such device or its chimney.

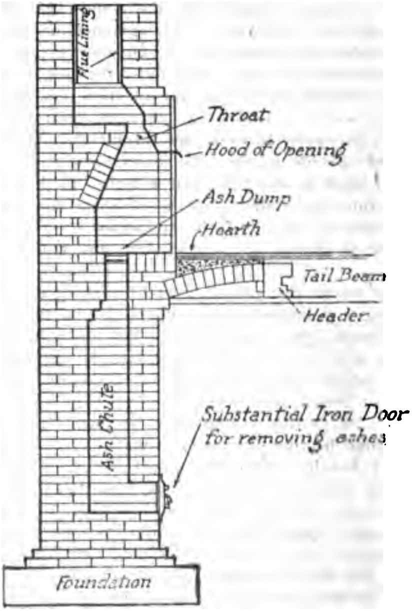

FIG. 30.—A thoroughly safe and substantial form of fireplace construction.

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13. When a building or structure extends more than 10 feet above the roof of an adjoining building or structure, the owner of the higher building, if requested in writing during its construction by the owner of the adjoining building or structure, shall at his own expense extend the adjoining flues of such adjoining building to the same height as the chimneys of his building, or shall supply sufficient flues connecting such adjoining flues with the chimneys of his building.

14. All fireplaces and chimney breasts where mantels are placed, whether intended for ordinary fireplace use or not, shall have trimmer arches or other approved fireproof construction supporting hearths. The arches and hearths shall be at least 20 inches in width measured from the face of the chimney breast, Fig. 50. The arches shall be of brick, stone, terra cotta or reinforced concrete of approved thickness. The length of the trimmer arch and the length of the hearth shall be not less than the width of the chimney breast. The hearth shall be of brick, stone, tile or other approved fireproof material. False fireplaces shall only be permitted against unfurred masonry walls.

15. No coal burning heater shall be placed in a fireplace, which does not conform to the foregoing requirements and have an incombustible mantel. No wood mantel or other woodwork shall be placed within 8 inches of the side nor within 12 inches of the top of any open fireplace. No combustible summer piece or fireboard shall be used in connection with any open fireplace. The firebacks of all fireplaces shall be of solid masonry not less than 8 inches thick.

16. When a grate is set in a fireplace, a lining of firebrick at least 2 inches in thickness shall be added to the fireback, or soapstone, tile or cast iron may be used, if solidly backed with brick or concrete.

All flue-holes when not in use shall be closed with tight-fitting metal covers.

Protection of woodwork around chimneys, Sec. 77.

SECTION 179. SMOKE PIPES.—1. No smoke pipe shall pass through any floor, nor through a non-fireproof roof. Smoke pipes for large cooking ranges, hot air furnaces, low pressure steam or hot water boilers shall be not less than 18 inches below any wood lath and plaster or other combustible ceiling, unless at least the upper half of such smoke pipe is properly protected by 1 inch or more of asbestos covering or its equivalent, or by a metal casing spaced 2 inches from the upper half of the pipe. If so protected smoke pipes shall be not less than 9 inches from any wood lath and plaster construction, woodwork or other combustible material. Smoke pipes from ordinary stoves shall be not less than 9 inches from any exposed woodwork.

2. Where a smoke pipe passes through a wood lath and plaster or other combustible partition or wall, a section of the partition or wall shall be removed and the smoke pipe so placed that no part of it shall be nearer than 12 inches to any remaining combustible part of the partition. The section of the partition or wall so removed shall be replaced by approved fireproof material only, and an air space of at least 2 inches shall be preserved on all sides of the smoke pipe.

SECTION 180. HEATING FURNACES AND APPLIANCES.—1. High pressure steam boilers, bakery ovens or furnaces in which fires are maintained producing a high degree of heat, shall rest on the ground, a trimmer arch, or a fireproof floor constructed in accordance with Section 111.

2. Low pressure heating boilers, coffee roasters, fireheated candy kettles, laundry stoves, coal ranges without legs, and similar appliances where hot fires are used, shall rest upon fireproof foundations as above described. However, the Superintendent's written permission may allow them to be

placed upon wooden floors if the floors are protected by sheet metal or a ⅛ inch layer of asbestos building lumber, covered with not less than 4 inches of masonry set in cement mortar. Such masonry shall consist of one course of 4 inch hollow terra cotta, or of two courses of brick or terra cotta, at least one of which shall be hollow and be laid to preserve a free circulation of air throughout the whole course. Concrete may be substituted for a course of solid brick if desired. The masonry work shall be covered by sheet metal of not less than No. 26 gauge, so arranged as not to obstruct the ventilating passages beneath. Such hearths shall extend at least 12 inches on the sides, back, and front of the furnace, range or similar heating appliance; if solid fuel is used, the front extension shall be at least 24 inches. All stoves or ranges with legs shall be set on incombustible material which shall extend at least 24 inches in front when solid fuel is used.

NOTE.—Solid brickwork will conduct heat quite freely. There are records of numerous fires starting by the ignition of wooden flooring underneath single layers of brick which supported furnaces or ranges in which hot fires were maintained. Hence the necessity for the double layer and air space.

3. Any woodwork or wooden lath and plaster partition within 4 feet of the sides or back, or 6 feet from the front of any such boiler, furnace, or heating appliances, shall be covered with metal shields or other approved incombustible material to a height of at least 4 feet above the floor. This covering shall extend the full length of the boiler, furnace, or heating appliance, and to at least 5 feet in front of it. Such metal shields shall be so attached as to preserve an air space behind them. In no case shall such combustible construction be permitted within 2 feet of the sides or back of the heating appliance, or 5 feet in front of same.

4. Heating boilers shall be encased on sides and top by incombustible protective covering not less than 1½ inches thick, and the overhead clearance of such covered boilers and hot air furnaces shall be not less than 15 inches. Any woodwork within 2 feet of the top of such boilers or furnace shall be protected by a loose fitting metal shield, but such shields shall not be placed so as to form concealed spaces.

NOTE.—It is recommended that the room or rooms in which boilers and all power and operating machinery are located, shall be separated from other portions of the building by an 8-inch wall, having an approved fire door at each opening; such rooms not to have direct communication with the floor above.

All boilers to be separated from operating machinery by 8-inch walls, with approved fire doors at openings.

SECTION 181. STOVES AND RANGES.—1. No kitchen range or stove in any building shall be placed less than 3 feet from any woodwork or wooden lath and plaster partition, unless the woodwork or partition is properly protected by metal shields, in which case the distance shall be not less than 18 inches. Metal shields shall be so attached as to preserve an air space behind them.

2. Hotel and restaurant ranges shall be provided with a metal hood placed at least 9 inches below any wooden lath and plaster or wooden ceiling, and have an individual pipe outlet connected with a flue. The pipe shall be protected by at least 1 inch of asbestos covering, or its equivalent.

3. No furnace, boiler, range or other heating appliance shall be placed against a wall furred with wood.

SECTION 182. HOT AIR PIPES AND REGISTERS.—1. All stone or brick hot air flues shall be lined with tin or other suitable sheet metal or burnt clay pipe.

2. Horizontal hot air furnace pipes shall be placed at least 6 inches below wooden floor beams or wooden lath and plaster ceiling; if the floor beams

or ceiling are protected by metal lath and plaster, or if the woodwork be covered with loose fitting tin, or the pipe be covered with at least ½ inch of corrugated asbestos, the distance from the woodwork may be reduced to not less than 3 inches.

3. Cold air ducts for hot air furnaces shall be made of incombustible material.

4. Hot air pipes where passing through combustible partitions or floors, must be doubled tin pipes with at least 1 inch air space between them.

No hot air pipe shall be placed in a wooden stud partition or any wooden enclosure unless it be at least 8 feet horizontal distance from the furnace. Hot air pipes contained in combustible partitions shall be placed inside another pipe arranged to maintain ½ inch air space between the two on all sides, or be securely covered with ½ inch of corrugated asbestos. Neither the outer pipe nor the covering shall be within 1 inch of wooden studding, and no wooden lath shall be used to cover the portion of the partition in which the hot air pipe is located, Fig. 31. Hot air pipes in closets shall be double, with a space of at least 1 inch between them on all sides. The air space between pipes shall be open at bottom and closed at top.

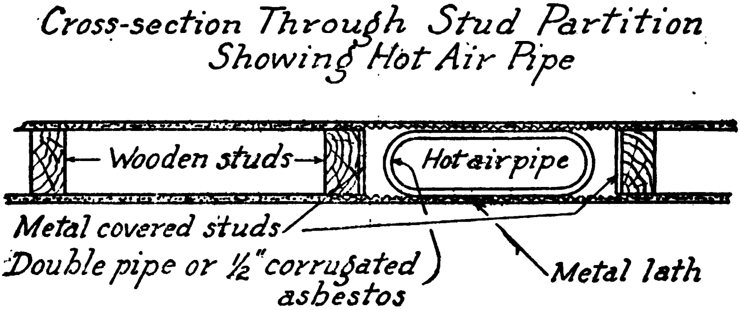
Cross-section Through Stud Partition
Showing Hot Air Pipe
Wooden studs
Hot air pipe
Metal covered studs
Double pipe or ½" corrugated asbestos
Metal lath

FIG. 31.—Protection of hot air pipe in wooden stud partition

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5. Every hot air furnace shall have at least one register without valve or louvres.

6. A register located over a brick furnace shall be supported by a brick shaft built up from the cover of the hot-air chamber; said shaft shall be lined with a metal pipe, and no woodwork shall be within 2 inches of the outer face of the shaft.

A register box placed in the floor over a portable furnace shall have an open space around it of not less than 4 inches on all sides, and be supported by an incombustible border.

Hot air registers placed in any woodwork or combustible floors shall be surrounded with borders of incombustible material, not less than 2 inches wide, securely set in place.

The register boxes shall be of metal, and be double; the distance between the two shall be not less than 1 inch; or they may be single, if covered with asbestos not less than ⅛ inch in thickness, and if all woodwork within 2 inches be covered with metal.

SECTION 183. STEAM AND HOT WATER PIPES.—No steam or hot water pipe shall be within 1 inch of any woodwork. Every steam or hot water pipe passing through combustible floors, or ceilings, or wooden lath and plaster partitions, shall be protected by a metal tube 1 inch larger in diameter than the pipe and be provided with a close-fitting metal cap on each side of the floor or partition. Fig. 32. All wooden boxes, or casings enclosing steam or hot water heating pipes, or wooden covers to recesses in walls in which steam or hot water heating pipes are placed, shall be lined with metal; and the pipes shall be kept at least 1 inch away from the walls of the box. Steam and hot water pipe coverings shall be of incombustible material.

NOTE.—Where waterproof floors are provided, it is important that metal sleeves which encase shafts or steam pipes should extend at least 6 inches above the floor level and be capped as above required. This provides a dam to prevent water flowing to floors below, if from any cause the floor should become flooded.

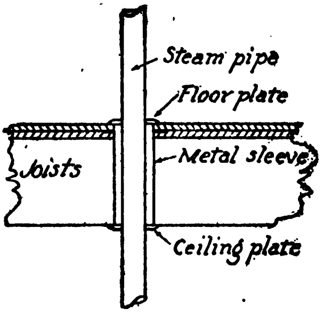

FIG. 32.—Protection of pipe or shaft openings through floors

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Steam pipes can ignite wood work in the following manners:

First—If the water is allowed to run low the steam becomes superheated, causing a true combustion.

Second—Pipes containing steam at the usual temperature may cause the secondary phenomenon of spontaneous combustion, as the steam pipes may slowly dry the wood, the moisture in time being vaporized which causes the wood to assume a state resembling charcoal, in which condition the glowing or combustion well known in the case of charcoal takes place spontaneously. The porosity of charcoal admits of the absorption of oxygen from the air, which may condense sufficiently to cause oxidation and heat the charcoal up to the ignition point. The sides of timber can readily bear a strong dead heat for an indefinite period without igniting, unless a cross section of the fibre, as exists around a live knot, presents itself to the heated surface, or if the end surface of the timber is exposed.

It is by the end that a piece of wood exposed to heat most readily ignites, as the gases which are generated in the timber pores are afforded a more liberal vent through the ends, thus exposing the inflammable gases to the direct action of the heat. Materials in the form of lint or dust, being in a finely divided state will oxidize more readily than when the same materials are in solid masses; such conditions can readily arise in flour mills, coal mines, or where any organic matter may be converted into dust. Iron may be prepared in such a finely divided state as to take fire on exposure to the air.

Frame Buildings

In no case shall a frame building with wooden siding be erected or altered, to extend within 5 feet of the side or rear lot line, nor within 10 feet of another building, unless the space between the studs on such side be filled solidly with not less than 2½ inches of brickwork or other equivalent incombustible material, and the entire exposed side be covered with at least a ⅛ inch layer of asbestos board, or ⅜ inch of plaster board back of the wooden siding. When such walls are thus filled and covered, their distance from a side or rear lot line may be reduced to 3 feet; or to 5 feet from another building. If the adjacent walls of two buildings have no openings, and are filled and covered as above specified, there need be no limitation as to distance between them.

NOTE.—It is recommended that when such buildings are nearer than 3 feet to a side or rear lot line, or 5 feet to another building, the cornices and overhanging eaves on the side or rear walls shall be of, or covered with, incombustible material. See Note in Section 85.

Floor beams and rafters in frame buildings shall be not less than 2 inches in thickness. All frame or wood buildings exceeding 15 feet in height shall have their sills secured to the foundations in an approved manner and be erected with sills, posts, girts and plates of suitable size and materials with proper mortise and tenon framing and braced with studs at all angles, but this shall not prohibit the use of balloon framing with proper sills and ribbon strip not less than 1¼ by 5 inches where diagonal sheathing is used, and provided that the outside walls are fire stopped at each floor level as required by Section 190, paragraph 3.

Timber stresses, Sec. 65.

SECTION 189. FOUNDATIONS FOR FRAME BUILDINGS.—1. The foundation walls of frame buildings or structures exceeding 15 feet in height shall rest on footings of stone or concrete not less than 8 inches in thickness. All footings shall extend at least 4½ inches outward from each side of the bottom of the foundation walls which rest upon them.

2. The bottom of footings for frame buildings shall rest upon solid ground at a depth at least equal to the frost line below the surface, unless solid rock occurs above this point; or upon piles or ranging timbers of wood where necessary. The foundation walls of frame structures exceeding 15 feet in height, if of stone, shall be not less than 16 inches thick, and if of brick or concrete, not less than 12 inches to the grade and 8 inches thick to the under side of the sill. If the foundation and first story walls are constructed of brick or concrete, the foundation walls shall be not less than 12 inches thick to the first tier of beams and 8 inches thick from the first to the second tier of beams, or if these walls are constructed of stone, they

shall be not less than 18 inches for the foundation walls and 16 inches for the first story wall.

3. Foundation walls of hollow building blocks shall be not less than 12 inches thick in any part.

4. For one story structures not used for dwellings, the thickness and depth of the foundation walls may be modified at the discretion of the Superintendent.

5. Footings and foundation walls shall be laid in cement mortar.

Section 190. Walls and Partitions in Frame Buildings.—1. In rows of frame houses, the dividing walls or partitions between houses shall be built of brick, terra cotta, concrete, or other approved incombustible material; or they may be built with 4 inch studs, filled solidly with brickwork laid in mortar, or with other incombustible material and covered on each side with at least ½ inch of metal lath and plaster, or plaster board. Such dividing partitions shall rest on masonry walls or wooden girders and shall extend to under side of roof boards, and a flush mortar joint shall be made between the roof boards and the wall or partition. In rows of more than three houses, every alternate division wall or partition shall be constructed of brick or concrete not less than 8 inches thick. These walls shall extend from front to rear, be solid without openings, and shall extend at least 2 feet above the roof, and be coped. If such parapet be of concrete, or if the top six courses of brick be laid in Portland cement the coping may be omitted.

Fire walls in frame buildings, Sec. 29.

2. The ends of floor beams entering such walls from opposite sides shall be so staggered or separated that there shall be not less than 4 inches of masonry between the beams where they rest on the walls.

3. Timber posts and girders or other approved supports may be used instead of brick fore and aft partitions, in cellars of frame buildings.

4. All stairway and other interior shafts in frame buildings which are required to be enclosed, including dumbwaiter shafts, may be constructed of wood, but they shall be covered with metal lath, or fibre plaster board

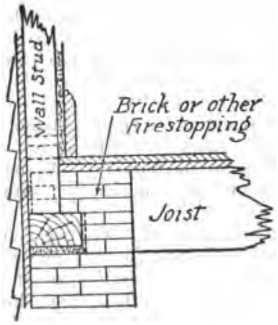

Fig. 33.—Fire-stopping of floor in frame building supported on foundation wall.

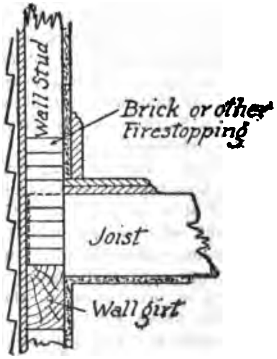

Fig. 34.—Fire-stopping of floor in frame building supported by timber wall girt.

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at least ½ inch thick, and plastered to a total thickness of ¾ inch; or the plaster board may be covered with sheet metal. Doors opening into such shafts shall be incombustible.

5. In all frame buildings which are to be lathed and plastered or otherwise sheathed on the inside, all stud walls and all partitions which rest directly over each other, shall be completely fire-stopped with brick work or other suitable incombustible material at each floor level. The spaces between the ends of floor joists which rest upon masonry foundation walls or upon wall girts, shall be filled solidly with fire-stopping material to the full depth of the joists, and the spaces between the studs shall be filled in the same manner to a height of 6 inches above the floor level. See Figs. 33 and 34. Partitions which rest over each other shall be firestopped as required in Section 97, paragraph 3. The firestopping shall be arranged to cut off all concealed draft openings, and form an effectual horizontal fire barrier between stories.

SECTION 191. CELLAR CEILING IN FRAME BUILDINGS.—The ceiling over the cellar or lowest floor in every frame building more than one story in height, except dwellings, shall be covered with metal lath and at least a ¾ inch coat of cement or cement-tempered plaster; or by a ½ inch layer of plaster board covered with a ¼ inch coat of plaster or with a layer of sheet metal.

SECTION 192. CHIMNEYS.—All chimneys in frame buildings shall conform to the requirements for chimneys in Section 178.

MILL CONSTRUCTION

This type of construction has undergone the test of time and has repeatedly demonstrated its merits both from an economic standpoint and as a source of protection against severe fire loss.

This title is often misapplied to structures which contain but a fractional portion of the salient features which are necessary in their entirety to warrant this title, as well as the merits due this type of construction.

The primary object of mill construction is to retard the progress of fire in its incipiency and in order to accomplish such a result a number of conditions are involved in the planning of this type of structure; the structural materials, arrangement of stairs and elevators; belt towers, floor areas, division of hazards due to the class of occupancy, and the proper fire protective devices must all be considered in their entirety, and if these conditions are not provided for as a whole the structure is defective in comparison with the standard type of mill construction. The paramount requirement of mill construction is stability; to ascertain the correct conditions as to the needs of the structure is of the utmost importance; the factors of the proposed floor loads due to machinery and merchandise, the possible amount of deflection, and conditions conducive to vibration, must first be determined before the arrangement and sizes of the structural members can be properly calculated. Special conditions due to the class of occupancy and the nature of the surrounding buildings have a direct bearing in the formulation of plans, all of which should be carefully considered in the planning of this type of construction.

Foundations.—The conditions as to the nature of the soil and underground strata should be positively determined over the entire area to be occupied by the structure before the plans are prepared; provision should be made to guard against unequal settlement, due to the arrangement of special foundations for machinery, tank towers, stacks, etc. Unequal settlement is a danger to be especially guarded against in mill construction. The supports for tanks used in connection with fire protective apparatus should be considered, unless such tanks are to be arranged on special independent towers.

Walls.—Good hard burned brick laid in best of lime or cement mortar is considered the best material for wall construction; walls

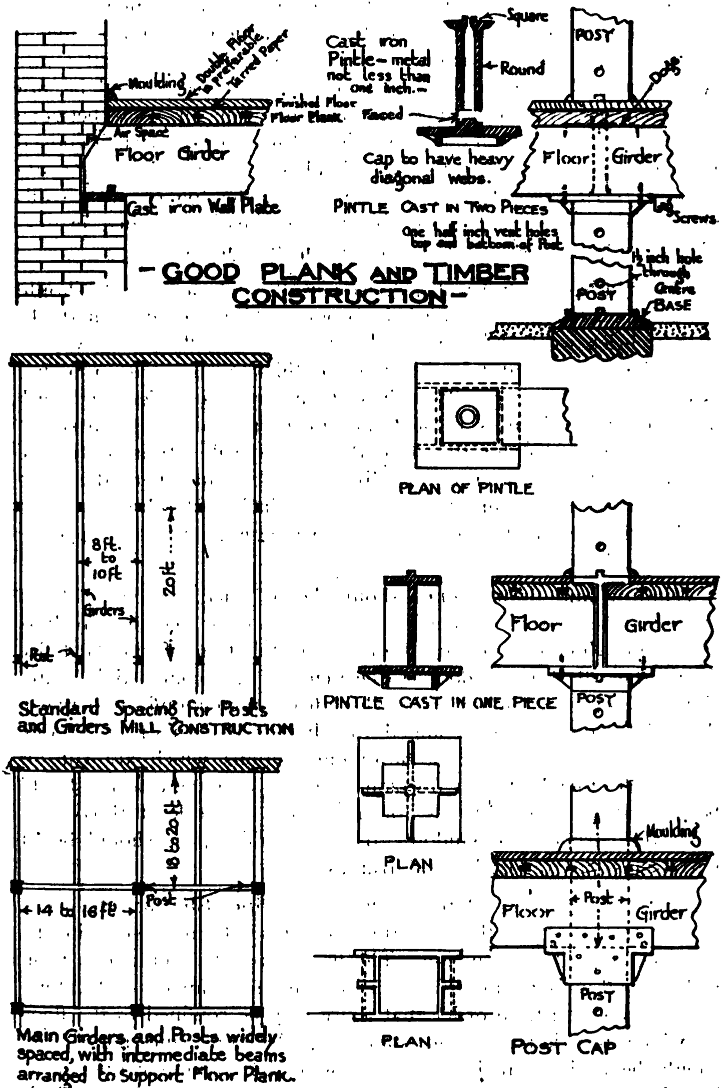
Moulding
Double Floor is preferable
Tarred Paper
Finished Floor
Floor Plank
Air Space
Floor Girder
Cast iron Wall Plate
Cast iron Pintle—metal not less than one inch.—
Square
Round
Faced
Cap to have heavy diagonal webs.
PINTLE CAST IN TWO PIECES
POST
Dogs
Floor Girder
Lag Screws.
One half inch vent holes top and bottom of Post
1½ inch hole through Centre
POST
BASE
—GOOD PLANK AND TIMBER CONSTRUCTION—
8 ft. to 10 ft.
20 ft.
Girders
Post
Standard Spacing for Posts and Girders MILL CONSTRUCTION
PLAN OF PINTLE
PINTLE CAST IN ONE PIECE
Floor
Girder
POST
18 to 20 ft.
14 to 16 ft.
Post
Main Girders and Posts widely spaced, with intermediate beams arranged to support Floor Plank.
PLAN
PLAN
Moulding
Floor
Post
Girder
Post
POST CAP

FIG. 35

in top story to be at least one foot thick and increased in thickness in the lower stories to support the required loads; outside walls as a rule arranged of pier or pilaster construction to admit of maximum window areas. Such walls should be well laid and all joints flushed up full with cement; piers in upper stories should be not less than twenty inches thick, non-bearing walls or walls between piers to be not less than one foot thick. Fire walls or walls exposed to fire from outside surroundings should be parapeted by carrying same at least three feet above roof lines; the top of such walls should be covered with a durable non-combustible coping, preferably terra cotta, such walls to be laid up in cement.

Fire Walls.—As fire walls, division walls and party walls should act as direct barriers to retard the progress of fire a sufficient thickness of brick work is required to make such a wall absolutely self-sustaining in case of fire; a minimum thickness of sixteen inches is considered necessary. If such walls are over sixty feet in length an additional thickness is necessary or proper piers or buttresses should be provided for the strengthening of wall. It is preferable to have no beams enter fire or division walls, but where the same are necessary there must be at least eight inches of solidly built up brickwork between the ends of beams if they enter walls at opposite sides.

Window and door arches should be of brick, window sills of brick laid on edge in cement, or sand stone. Door openings in division walls should be arranged for the installation of standard fire doors, the sills for fire doors to be made of non-combustible materials. All openings in any walls where fire can communicate between floors or rooms to be arranged for the installation of fire doors. Where angle walls exist at adjoining sections which are cut off from each other by fire or division walls the two angle walls should be treated as exposed walls for a distance of at least thirty feet from the corner, and windows, if any, in this space should be of wired glass in standard metal frames.

Stairs, Elevators, Belt Enclosures, Pipe Shafts, etc.—The proper treatment of these features is of vital importance in the planning of mill construction. The floors must be continuous from wall to wall without holes through the same for stairways, elevators, belts or pipe shafts in order that a fire may be confined to the floor in which it originates, and stairways, elevators, and main belts should be enclosed in brick towers, with the communicating openings into main buildings protected with standard fire doors which should be self-closing. In modern mills belts or ropes which may be used for transmission of power to the various floors are arranged in vertical belt towers, the walls of which are constructed of brick or non-combustible materials, and the power is transmitted by shafts through the walls in the several stories. Where openings are necessary they should be protected by standard fire doors.

Floors.—The floor planking should be of spruce or yellow pine three or more inches in thickness according to the spacing of the bay timbers and nature of the floor loads and machinery. The planking should be spiked directly to the floor timbers and kept at least two inches clear of the inside face of brick walls to allow for expansion; a quarter round moulding is generally placed around the inside along the wall and around columns.

The planking should be grooved for hard wood splines.

In bays eight feet and under, three inch splined plank is generally used. For bays eight to ten feet, four inch splined plank; in bays ten to twelve feet, six inch plank or two inch by six inch timbers placed solidly side by side on edge; in bays twelve to fourteen feet wide, planking should be eight to twelve inches thick, generally arranged with two inch by twelve inch timbers placed solidly side by side, thus giving the required thickness.

In the best work a double top floor is laid on the planking, the lower one being laid diagonally upon the plank. The upper or wearing floor should be of maple or birch laid lengthwise. With the double floor the worn sections may readily be replaced. The diagonal subfloor braces the entire floor area, reduces vibration and tends to distribute the floor load to the best advantage.

Between the planking and the top floor there should be two or three layers of heavy tarred paper laid to break joints, each layer to be mopped with hot tar or similar material to secure a reasonably water-tight and dust-tight floor. Floor scuppers should be arranged to reduce water damage in lower stories.

Basement or lower floors should preferably be of cement as rapid decay or dry rot is likely to ensue if wood floors are laid in such locations unless special provision is made to protect the wooden floors from deterioration.

The best method where wooden floors are required is to prepare a foundation of crushed stone, cinders or slag, covering the same with a thick layer of hot tar concrete, over which is laid tarred felt well mopped with hot tar or asphalt. The wood floor should be of two inch well seasoned plank, and pressed on the hot tar or asphalt foundation floor. The plank should be nailed on edge without perforating the waterproofing under it; the finished hardwood floor boards should be nailed across the plank. Suitable provision should be made for draining basement floors.

Roofs to be of three inch splined pine plank spiked to the roof timbers and covered with five-ply tar and gravel or approved composition roofing; roofs should pitch one-half inch to three-fourths inch per foot. Where there are exposing buildings the walls should be parapeted and coped with terra cotta.

Timbers and Columns.—No timbers less than six inches in width should be used. Timber should be of sound Georgia pine. Single sticks are preferred for sizes up to fourteen by sixteen inches, but owing to the market conditions large timbers are not always available, in which event it is customary to bolt two seven or eight inch by sixteen inch timbers together, without air space between. Timbers should not be painted, varnished or filled for several years on account of danger due to dry rot. The ends of timbers should be protected against dry rot by providing an air space in the masonry around the same. All timbers should be arranged to rest on cast iron plates or beam boxes in the walls and on cast iron caps on the columns. Beam boxes are of value as they strengthen the walls and distribute the loads evenly. The laying of the brickwork and erecting the beams is also facilitated. The proper air space around end of beams is also insured by this arrangement.

Columns to be of southern pine. There should be a one and one-half inch hole bored through the centre, and one-half inch vent holes top and bottom. In making calculations to safely bear the superimposed loads allowance should be made to provide for sectional areas of columns which will carry the loads after two inches of their diameter have been reduced to charcoal by fire.

Columns should be accurately set on pintles, which may be cast in one piece including the cap, or separately.

Where floor loads are heavy, cast iron or steel columns are often found more practical than wood, but the use of structural metal should be avoided unless it is thoroughly fireproofed. No ordinary fire is likely to consume an upright post of twelve inches diameter, since the charring of the surface tends to preserve the inner and untouched core; experience has demonstrated the value of mill construction, especially when buildings are equipped with proper fire protective devices, but it is seldom wise to incorporate this type of construction in buildings over four stories in height. In fact with the competitive costs of fire proof construction, it is becoming more feasible to construct buildings requiring calculations for heavy floor loads entirely of fireproof materials, especially structures over four stories in height and where the floor loads are 150 pounds to the square foot and over.

Mill construction or slow-burning construction requires the assembling of the heavy timbers in such a manner as to retain the full strength of the timbers, whether in columns, beams or girders. As all timber is more or less subject to shrinkage due to the present methods of seasoning, and, in addition, the physical changes constantly taking place in manufacturing or warehouse properties, this condition must be properly met and curtailed as much as possible in the assembling of the beams and girders. Otherwise, the settlement in girders or beams might necessitate cutting out the flooring, or where shafting is arranged in connection with hangers supported by the beams, the unequal alignment is likely to cause hot bearings in addition to constant expenditures in the maintenance of proper alignment.

Mill construction originally involved the assembling of the posts and girders in such a manner that the posts were spaced from eight to ten feet apart, the girders being supported directly over the posts. Modern requirements demand the maximum available amount of unobstructed floor space thus eliminating as many posts as possible, with the result of a change in the method of supporting the floor planking. The elimination of posts requires the adoption of main girders to carry intermediate beams; the method of supporting the beams from the girders largely determines the proper rating of this class of construction, as the framing is governed by the efficiency of the connecting support or hanger.

Wrought iron and steel stirrups have been used extensively for the support of floor beams, headers, and girders, and until recent years no comparative tests have been made. Several accidents and scientific tests have demonstrated the inherent weakness which always exists in this form of support. There is a tendency to fail by the bending of the stirrup as well as the crushing of the wood at the top of the supporting beam which causes the stirrup to rise on the opposite side, with the constant danger of the stirrup slipping over the carrying beam.

Patent joist hangers are on the market which have been successfully tested and are now approved by the underwriters' organizations. These hangers have been designed with a view to minimizing settlement due to shrinkage in the main supporting beams and girders.

Wall hangers should incorporate the same principles as joist hangers; the object being to secure a proper distribution of the loads over the bearing surface of the masonry, while at the same time possessing the requisite tensile strength in the sides and bottom. A proper wall hanger will meet the following requirements:

1st. The regular bond of masonry will not be broken. 2d. The bearing of timbers on the walls will be adequate. 3d. Secure anchorage will be maintained. 4th. Dry-rot will be reduced to a minimum. 5th. The timbers will be self-releasing in case of fire.

SEMI-MILL CONSTRUCTION

Semi-mill or compromise construction is the stepping stone between the ordinary joisted construction and standard mill construction; instead of a number of joist spaced from twelve to eighteen inches apart, heavier timbers are used and spaced from three to six feet apart, these timbers being designated as beams in semi-mill construction. In both joisted and semi-mill construction the joist and beams are generally carried by main girders which are spaced from sixteen to twenty-five feet apart, the common method being to support the beams on iron hangers or stirrups where they intersect the main girders. This arrangement is used frequently instead of the preferable method of allowing the beams to rest on top of the girders, the stirrup arrangement being used to save head room. Large beams are frequently hung in stirrups having but two or three inches of bearing, which requires extra ties or straps. With such an arrangement the beams are not self-releasing and are likely to cause severe damage in case of shock or vibration, or of conditions due to unequal loading on the floors.

The arrangement of floor timbers in semi-mill construction often defeats an object which is of vital importance, that is, in securing the utmost effectiveness from the fire protective devices, whether from hose streams or automatic sprinklers, as the beams often obstruct the full action of the hose streams or automatic sprinklers. There is a variance of opinion as to the consistent arrangement and number of automatic sprinklers required for the proper protection of buildings so constructed owing to the obstruction to distribution occasioned by the beams.

The stairs and elevators in this type of building are often arranged within the main areas instead of within substantial brick towers as in standard mill construction.

The introduction of wood sheathing and light frame partitions is a frequent condition found, which defeats the object of good construction. The roof construction is frequently of light timbers, with the introduction of unnecessary hip or valley rafters which complicate and add to the expense of automatic sprinkler equipments. While buildings of this type are as a rule superior to joisted or quick burning construction they are vastly inferior to a mill of standard construction.

COMPOSITE CONSTRUCTION—STEEL AND PLANK

The requirements for certain classes of manufacture call for a maximum amount of unobstructed floor space, or clear girder spans which are impractical by the use of plank and timber forms of construction. Well seasoned, sound timber, suitable for girders of long spans, is rapidly becoming scarce in most markets, or else the prices are becoming prohibitive. Solid sticks of timber for spans over 25 feet are impractical when used for floor girders in connection with manufacturing or warehouse properties. Structural steel I beams fill the requirements for spans up to 30 feet. Building operations in the zone of the steel markets, where the materials and expert labor are available, have been successful through the employment of structural steel columns and girders, with the introduction of plank floors.

In the designing of this type of construction, it is necessary to fabricate the metal to meet the class of proposed occupancy. The conditions as to fixed or vibrating machinery should be well considered in the design and spans of the structural members. Provision should always be made for the proper tieing of the structural members to the wall masonry, and the possible deflection or vibration of beams and girders should be considered in the design.

As structural metal work is readily destroyed under the influence of fire, provision should be made in the designing of columns, to arrange the units or sections in such a manner as to readily admit of the application of fireproofing materials.

The columns in this class of construction are usually fireproofed by the application of wire lath and cement plaster. Some engineers prefer to encase the columns in solid concrete, which is poured in wooden forms arranged around the structural metal work. A minimum thickness of 2 inches between the metal and concrete should always be provided. With the column solidly encased in concrete, the danger from rust is remote; and with solidly encased columns and beams, these structure members become more monolith in character, which tends to reduce vibration and deterioration.

The floor planking is secured to the I beams by arranging a timber, usually 4 inches thick, on the top flange of the beam. In order to secure a maximum amount of rigidity this timber, or nailing piece, should be bolted to the flange of the beam, suitable holes having been punched at the steel mill for this purpose. The splined plank and hardwood wearing floor can be arranged similarly to the standard mill constructed floor.

The desired stiffness of the floor between the girders may be secured by providing a suitable thickness of planking, which would be governed by the spacing of the girders and conditions due to floor loads or specific kind of machinery.

As this type of floor is practically a single unit, and as longitudinal contraction is likely to ensue under certain conditions, especially where the floors may be constructed by joists or timbers on edge spiked together, provision should be made for a continuous joint in the under flooring, at intervals.

The spacing of columns and girders is governed by the requirements of the structure; girder spacings of from 6 to 12 feet are often adopted and columns are spaced from 8 to 20 feet.' In the greater widths, the cross girders are often arranged to bear on main longitudinal girders running from column to column.

This type of construction admits of a maximum amount of floor area; permits provision being made for a maximum amount of light, and, with the plank floors, machinery and shafting can be rearranged or installed at a minimum cost. Machine shops and light manufacturing processes have been successfully arranged in this type of structure. Properties constructed for tenant purposes are a success in this form of construction as changes or new installations in machinery can be accomplished without destroying the floor construction, and such changes can be made at a minimum cost.

FIREPROOF FLOORS BETWEEN STEEL BEAMS

Monolithic Construction

Monolithic Construction.—This type of construction consists of a structural steel frame with segmental arches or flat slabs between or over the steel beams. The material is generally placed in position in a plastic state on temporary wood or permanent metal centering and allowed to set or harden. In the monolithic construction the thrust is largely eliminated and there is no liability of settling or displacement of parts. If the insulating material is properly made and applied, such material should be of a nature to resist the action of fire with the resultant expansion stresses due to sudden application of hose streams. Sufficient material should be used to insure adequate protection to the structural members. A concrete made of cinders in such a manner that the voids will be well filled provides a good protection for structural steel against corrosion as well as fire. Cinder concrete, however, in a damp atmosphere where the cinders are not imbedded in a sufficient matrix of cement mortar would be conducive to the rapid corrosion of the structural metal work. It is important that the structural metal be cleaned of mill scale and rust prior to the placing of the protective materials. Some authorities advocate covering the surface of the metal with a simple mixture of Portland cement and sand as an extra precaution.

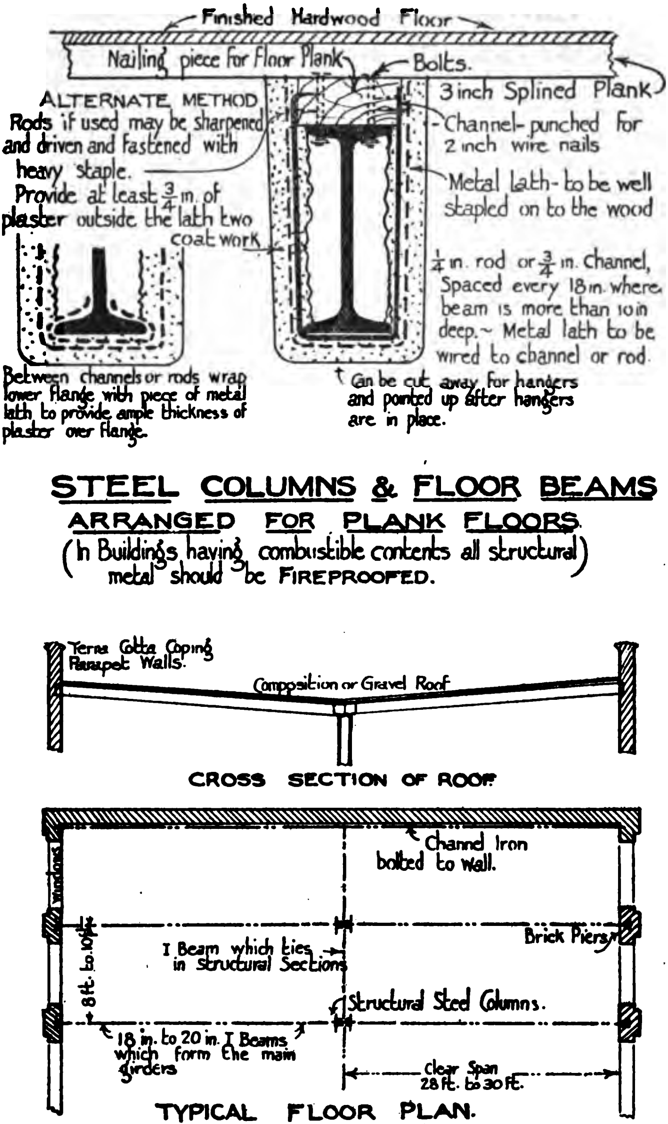
Finished Hardwood Floor
Nailing piece for Floor Plank
Bolts.
3 inch Splined Plank
ALTERNATE METHOD
Rods if used may be sharpened and driven and fastened with heavy staple.
Provide at least 3/4 in. of plaster outside the lath two coat work
Channel-punched for 2 inch wire nails
Metal lath - to be well stapled on to the wood
1/4 in. rod or 3/4 in. channel, Spaced every 18 in. where beam is more than 10 in deep. ~ Metal lath to be wired to channel or rod.
Between channels or rods wrap lower flange with piece of metal lath to provide ample thickness of plaster over flange.
Can be cut away for hangers and pointed up after hangers are in place.
STEEL COLUMNS & FLOOR BEAMS ARRANGED FOR PLANK FLOORS.
(In Buildings having combustible contents all structural metal should be FIREPROOFED.)
Terra Cotta Coping Parapet Walls.
Composition or Gravel Roof
CROSS SECTION OF ROOF
Channel Iron bolted to wall.
Windows
Brick Piers
I Beam which lies in Structural Sections
8 ft. to 10 ft.
Structural Steel Columns.
18 in. to 20 in. I Beams which form the main girders
Clear Span 28 ft. to 30 ft.
TYPICAL FLOOR PLAN.

FIG. 36

Construction Consisting of Assembled Parts

Assembled Parts.—This system involves the use of segmental or flat arches constructed of hollow tile, which arrangement makes it necessary to provide for the proper tieing of the floor beams to take up the thrust of the arches. It is of vital importance that the arches be properly erected, and that all joints be perfect, allowing full bearing over the entire surface of the joints. Special precautions should be taken in the case of "End Construction"—that is where the cellular spaces and webs run at right angles to the beams,—the blocks should be accurately set so that the adjacent ribs or webs come opposite each other and form a continuous rib or web from skewback to skewback. With imperfect joints arches of this class will settle, causing cracks, which will not only destroy the finished ceiling, but cause failure as a fire retardant.

In arches adjacent to exterior walls the tie rods should be carefully protected so as to prevent thrust against the walls in case of fire.

Construction with Light Metal Constituents

Construction with Light Metal Constituents.—Fireproofing material in the form of a flat arch or flat slab acts like a beam, the upper portion of the section being in compression and the lower portion in tension. As no building materials adapted for this purpose are as strong in tension as in compression, light metal elements or units are introduced to strengthen that portion of the section that is in tension. By the use of metal as a reinforcing material a much thinner and lighter construction of the requisite strength may be obtained. In assembled construction the metal elements are imbedded in the mortar joints. In monolithic construction the metal is imbedded in the material while in a plastic state.

The metal generally consists of steel in the form of wire, rods. bars, or sheet metal expanded into open meshes. If properly imbedded the metal adds greatly to the strength of the construction. As that portion of the material which is in tension is usually the underside of the beam or slab, the metal in order to develop its maximum efficiency should be located as far as possible from the neutral axis or near the under surface of the construction. In this position, however, it is very much exposed and in case of fire of any magnitude the heat would soon render the metal constituents valueless. As an element of strength in constructions of this class, the imbedded metal should be located as far as practicable from the under surface.

Fireproofing.—Types of fireproof floors in which the under surface of the materials of construction is below the lower flange of the steel beams afford generally a better protection for the beams than those types in which the beams project below the flooring and are protected by a covering. In the latter case three sides of the beam or girder covering are exposed to the flame, and heat in case of fire. The thickness of covering in such forms of construction should be carefully designed so as to provide suitable protection as the special conditions may warrant.

For warehouses, factories, stores and such buildings which may be filled with inflammable and other goods, and in which the floors are subject to heavy moving or jarring loads, the segmental arch form of construction will generally be found the strongest, safest and most economical.

For public buildings, libraries, and other high class buildings in which expensive interior finish enters, the monolithic construction with flat ceilings gives the best results. The finished ceilings are generally suspended under the rough constructive members, the finished plastering being applied to wire or expanded metal. The monolithic construction will preserve the integrity of the floor finish and the wire ceilings if properly constructed will prevent the cracking and discoloration of the finished plaster work.

FLOOR DRAINAGE AND SCUPPERS

Water damage in many cases is much in excess of the actual fire loss. To guard against this, thoroughly waterproof floors are essential; even in apartments, as evidenced by the heavy water damage in the Alwyn Apartment fire in New York, this waterproofing should be provided. In this case, although the building was fireproof, the water necessary to extinguish a fire on one floor seeped through to several floors below, because sufficient attention had not been paid to waterproofing.

In joisted buildings, the flooring is usually so thin and poorly laid as to readily let water through, but even with such floors, if a proper pitch is given to the floor to drain to a doorway, stairwell or elevator opening, much damage can be prevented by salvage corps and firemen by sweeping the water away.

In mill or fireproof buildings the waterproofing is a simpler matter and requires only a little care in the laying or placing of the floors and the flashing around the walls.

It is considered good practice to build floors with a pitch of one inch in twenty feet;—basement floors should be pitched towards and drained to elevator pits which should be three feet deep and connected to sewer or a well to carry off the water.

Standard brick stair and elevator towers often provide good means for disposing of water but there is more or less delay in sweeping up, especially where the floors are not properly graded or where the floor areas are large; the drains and pits at bottom of elevator shafts are frequently too small to carry off quantities of water, such a condition could readily lead to heavy water losses in basements containing perishable materials.

To secure an efficient watertight floor, it is necessary to arrange not only a suitable surfacing, but special precautions should be taken at all openings where pipes or conduits extend through the floors, watertight metal thimbles should be arranged around pipes, suitable curbing should be arranged at the walls and around columns.

In all buildings where goods are stored or manufactured, and especially if the building is equipped with sprinklers, there should be properly designed scuppers of sufficient capacity to prevent the water rising to a height that will damage goods.

Several makes of scuppers are on the market but these are patented. The most common type is one extending through the side wall, with a slight slant and with a wider mouth on the inside. Another type consists of pipes extending down through the various stories with inlet slots.

There are no insurance regulations covering scuppers; a National Fire Protection Association Committee issued an advance report on this subject at the annual meeting in 1915, but it was not adopted, because it described patented articles.

There are several features which must be covered: they must be of such design as not to allow any water to stand on the floor before starting discharge, must not allow passage of fire or smoke from one floor to another and must be of such capacity and in such number as to prevent water from a reasonable number of sprinkler heads or fire streams flooding the floor sufficiently to wet goods on 4 to 6-inch skids. In addition they must be so located and protected as to give a free opening and not be stopped up by the piling of goods. Also they must not be of a design that will allow such an amount of cold air in the winter time that there will be a tendency to stuff paper or rags in the opening.

ROOF COVERINGS

Roof Coverings inspected and classified in accordance with Underwriters' Laboratories' "Standard for Roof Coverings, Test Specifications and Classification Schedule," bear labels attached to each container of finished roofing or roofing material. Labels for different classes are lettered and colored as follows:

Letter	Color Background	Lettering
Class A	White	Orange
Class B	White	Red
Class C	Red	Yellow
Class D	Yellow	Red
Class E	Red	White
Class F	Orange	White

As regards the fire hazard, roof coverings are classified as (1) Standard, (2) Fire Retarding, and (3) Flammable.

1. Standard.—Includes the Underwriters' Laboratories' Classes A and B.
2. Fire Retarding.—Includes the Underwriters' Laboratories' Classes C, D, E and F.
3. Flammable.—Includes the Underwriters' Laboratories' Classes G and H.

For dwellings, standard or fire retarding roof coverings are acceptable. Where flammable roof coverings are used on this class of property, the increased fire hazard should be recognized.

For mercantile and other business property standard roof coverings should be used. In general where fire retarding or flammable roof coverings are used on this class of property, the differences in the fire hazard should be recognized.

Class A includes roof coverings which are not flammable and do not carry or communicate fire; which afford a very high degree of heat insulation to the roof deck; which possess no flying brand hazard; which do not slip from position when exposed to high temperature, and which are durable and do not require frequent repairs.

Class B includes roof coverings which are not readily flammable and do not carry or communicate fire; which afford a high degree of heat insulation to the roof deck; which possess little or no flying brand hazard; which do not slip from position to a serious degree when exposed to high temperature, and which are durable and do not require frequent repairs.

Class C includes roof coverings which are not readily flammable and do not carry or communicate fire to a serious degree; which afford at least a moderate degree of heat insulation to the roof deck; which possess little or no flying brand hazard; which do not slip from position to a serious degree when exposed to high temperatures, and which are durable but may require occasional repairs.

Class D includes roof coverings which are not readily flammable and do not carry or communicate fire to a serious degree; which afford at least a slight degree of heat insulation to the roof deck; which may possess a slight flying brand hazard; which do not slip from position to a serious degree when exposed to high temperatures, and which are durable, but may require occasional repairs.

Class E includes roof coverings which are not readily flammable but will carry and communicate fire when exposed to severe fire conditions; which afford at least a slight degree of heat insulation to the roof deck; which may possess a slight flying brand hazard; which do not slip from position to a serious degree when exposed to high temperatures; which are durable but may require maintaining.

Class F includes roof coverings which are not readily flammable but will carry and communicate fire when exposed to severe fire conditions; which afford but little heat insulation to the roof deck; which may possess a slight flying brand hazard; which do not slip from position to a serious degree when exposed to high temperatures, and which are durable but may require maintaining.

Class G includes roof coverings which are flammable and will carry and communicate fire when exposed to fire conditions; which afford little or no heat insulation to roof deck; which possess a serious flying brand hazard; which slip from position to a serious degree when exposed to high temperatures, and which may require frequent repairs and renewals.

Class H includes roof coverings which are a menace to property and which have repeatedly demonstrated their hazardous nature as conflagration breeders.

The following manufacturers are equipped to furnish labeled roofings and roofing materials as described below:

Built Up Type

CLASS A.—

Barrett Specification Roof Coverings with gravel or crushed slag composed of Barrett Specification Roofing materials.

Built up type, non-combustible surfaced. Five plies. Flashings and trimmings of 16 oz. copper or heavier. Assembled in accordance with Barrett specifications. Attached by nailing, mopping of pitch, or both. Limited to non-combustible roof decks of standard construction having inclines not exceeding 1 inch to foot horizontal.

New York, Barrett Mfg. Co., 17 Battery Pl.

J. M. Specification Asbestos Roof Coverings, three-ply pattern, composed of J. M. Specification Asbestos Roofing materials.

Built up type, smooth surfaced. Three plies. Flashings and trimmings. J. M. Asbestos Flashing Material or 16 oz. copper or heavier. Assembled in accordance with J. M. specifications laid directly over and attached by cement and nails to non-combustible roof decks having inclines not exceeding 3 inches to foot horizontal.

New York, Johns-Manville Co., H. W., Madison Ave. and 41st St.

CLASS B.—

Barrett Specification Roof Coverings with gravel or crushed slag composed of Barrett Specification Roofing materials.

Built up type, non-combustible surfaced. Five plies. Flashings and trimmings of 16 oz. copper or heavier. Assembled in accordance with Barrett specifications. Attached by nailing, mopping of pitch, or both. Limited to combustible and non-combustible roof decks having inclines not exceeding 3 inches to foot horizontal.

New York, Barrett Mfg. Co., 17 Battery Pl.

J. M. Specification Asbestos Roof Coverings, three-ply pattern, composed of J. M. Specification Asbestos Roofing materials.

Built up type, smooth surfaced. Three plies. Flashings and trimmings. J. M. Asbestos Flashing Material or 16 oz. copper or heavier. Assembled in accordance with J. M. specifications laid directly over and attached by cement and nails to non-combustible roof decks having inclines not exceeding 6 inches to foot horizontal.

Four and five-ply patterns.

Built up type, smooth surfaced. Four or five plies. Flashings and trimmings J. M. Asbestos Flashing Material or 16 oz. copper or heavier. Assembled in accordance with J. M. specifications, laid directly over and attached by cement and nailing to combustible and non-combustible roof decks, capable of receiving and retaining nails, where inclines do not exceed 6 inches to foot horizontal.

New York, Johns-Manville Co., H. W., Madison Ave. and 41st St.

Prepared Type

CLASS B.—

Brooks Brand Asbestos Roof Coverings. Four-ply pattern. Composed of Brooks Brand Asbestos Roofings.

Prepared type, smooth surfaced. Single thickness. Attached by nailing. Limited to combustible and non-combustible roof decks capable of receiving and retaining nails and to inclines exceeding 3 ins. to ft. horizontal.

New York, Johns-Manville Co., H. W., Madison Ave. and 41st St.

CLASS C.—

Brooks Brand Asbestos Roof Coverings. Three-ply pattern. Composed of Brooks Brand Asbestos Roofings.

Prepared type, smooth surface. Single thickness. Attached by nailing. Limited to combustible and non-combustible roof decks capable of receiving and retaining nails and to inclines exceeding 3 ins. to ft. horizontal.

New York, Johns-Manville Co., H. W., Madison Ave. and 41st St.

CLASS F.—

Arc Ready Roof Coverings. Two and three-ply patterns. Composed of Arc Ready Roofings.

Prepared type. Smooth, sanded, or grit surfaced, single thickness. Attached by nailing. Limited to combustible and non-combustible roof decks capable of receiving and retaining nails and to inclines not exceeding 3 inches to foot horizontal.

Chicago, Amalgamated Roofing Co., 431 S. Dearborn St.

Mule-Hide Roof Coverings. Two, three and four-ply patterns. Composed of Mule-Hide Roofings.

Prepared type. Smooth surfaced. Single thickness. Attached by nailing. Limited to combustible and non-combustible roof decks capable of receiving and retaining nails and to inclines not exceeding 3 inches to foot horizontal.

Chicago, Lehon Co., The, W. 45th St. and Oakley Ave.

Arrow and Protection Brands Asphalt Ready Roof Coverings. Composed of Arrow or Protection Brand Roofings.

Prepared type, grit surfaced. Single thickness. Attached by nailing. Limited to combustible and non-combustible roof decks capable of receiving and retaining nails and to inclines exceeding 3 ins. to the ft. horizontal.

New York, N. Y., Asphalt Ready Roofing Co., 9 Church St.

Regal Brand Asbestos Roof Coverings. Two and three-ply patterns. Composed of Regal Brand Asbestos Roofings.

Prepared type, smooth surface. Single thickness. Attached by nailing. Limited to combustible and non-combustible roof decks capable of receiving and retaining nails and to inclines exceeding 3 ins. to ft. horizontal.

New York, Johns-Manville Co., H. W., Madison Ave. and 41st St.

Ru-ber-oid Roof Coverings. Heavy and extra heavy patterns; and colored Ru-ber-oid heavy pattern. Composed of Ru-ber-oid roofings.

Prepared type, smooth surfaced. Single thickness. Attached by nailing. Limited to combustible and non-combustible roof decks capable of receiving and retaining nails and to inclines exceeding 3 inches to the foot horizontal.

New York, Standard Paint Co., The, Woolworth Bldg.

Vulcanite Prepared Asphalt Roof Coverings. Two, three and four-ply standard, extra heavy patterns. Composed of Vulcanite Prepared Roofings.

Prepared type. Smooth, sanded and grit surfaced. Single or laminated. Attached by nailing. Limited to combustible and non-combustible roof decks capable of receiving and retaining nails and to inclines exceeding 3 inches to the foot.

Chicago, Ill., Patent Vulcanite Roofing Co., Oakley Ave. and 49th St.

Shingle Type

CLASS B.—

Asbestos Century Shingle Roof Coverings. Composed of Asbestos Century shingles.

Thatched type, smooth surfaced. Three thicknesses. Flashings and trimmings 16-oz. copper, No. 26 gauge galvanized iron or heavier, and Asbestos Ridge Rolls. Assembled at building, laid directly over and attached by nailing to roof decks capable of receiving and retaining nails, where inclines exceed 4 inches to the foot horizontal.

Asbestos Century Shingle Roof Coverings, laid American method. Composed of Asbestos Century Shingles.

Thatched type, smooth surfaced. Two thicknesses. Attached by nailing. Limited to combustible and non-combustible roof decks capable of receiving and retaining nails and to inclines exceeding 4 inches to foot horizontal.

Ambler, Pa., Keasby & Mattison Co.

J-M Transite Asbestos Shingle Roof Coverings. Two thicknesses. Laid American method. Composed of J-M Transite Asbestos Shingles.

Thatched type, smooth surfaced. Flashings and trimmings 16-oz. copper, No. 26 gauge galvanized iron or heavier, and J-M Transite Asbestos Ridge Rolls. Attached by nailing. Limited to decks capable of receiving and retaining nails and to inclines exceeding 4 inches fall to the foot horizontal.

New York, Johns-Manville Co., H. W., Madison Ave. and 41st St.

CLASS C.—

Asbestos Century Shingle Roof Coverings, laid French method. Composed of Asbestos Century Shingles.

Thatched type, smooth surfaced. One thickness. Attached by nailing. Limited to decks capable of receiving and retaining nails and to inclines exceeding 4 inches fall to foot horizontal.

Ambler, Pa., Keasbey & Mattison Co.

J-M Transite Asbestos Shingle Roof Coverings. One thickness. Laid French method. Composed of J-M Transite Asbestos Shingles.

Thatched type, smooth surfaced. Flashings and trimmings 16-oz. copper, No. 26 gauge galvanized iron or heavier, and J-M Transite Asbestos Ridge Rolls. Attached by nailing. Limited to decks capable of receiving and retaining nails and to inclines exceeding 4 inches fall to the foot horizontal.

New York, Johns-Manville Co., H. W., Madison Ave. and 41st St.

CLASS E.—

Nu-tile Asphalt Shingle Roof Coverings. Extra heavy pattern. Composed of Nu-tile Asphalt Shingles.

Thatched type, grit surfaced. Three thicknesses. Attached by nailing. Limited to combustible and non-combustible roof decks capable of receiving and retaining nails and to inclines exceeding 4 inches to foot horizontal.

Chicago, Ill., Amalgamated Roofing Co., 431 S. Dearborn St.

Reynolds Flexible Asphalt Slate Shingle Roof Coverings. Composed of Reynolds Flexible Asphalt Slate Shingles.

Thatched type, grit surfaced. Three thicknesses. Flashings and trimmings of same material, 16-oz. copper, No. 26 gauge galvanized iron or I. C. Terne Plate, 20-lb. coating or heavier. Assembled at buildings, laid directly over and attached by nailing to roof decks capable of receiving and retaining nails, where inclines exceed 4 inches to the foot horizontal.

Grand Rapids, Mich., Reynolds Asphalt Shingle Co., H. M.

CLASS F.—

Nu-tile Asphalt Shingle Roof Coverings. Heavy pattern. Composed of Nu-tile Asphalt Shingles.

Thatched type, grit surfaced. Three thicknesses. Attached by nailing. Limited to combustible and non-combustible roof decks capable of receiving and retaining nails and to inclines exceeding 4 inches to foot horizontal.

Chicago, Ill., Amalgamated Roofing Co., 431 S. Dearborn St.

Arc-Strip Shingle Roof Coverings. Heavy pattern. Composed of Arc Shingle Strips.

Thatched type, grit surfaced. One thickness. Attached by nailing. Limited to combustible and non-combustible roof decks capable of receiving and retaining nails and to inclines exceeding 4 inches to foot.

Chicago, Ill., Amalgamated Roofing Co., 431 S. Dearborn St.

PROTECTION OF WALL OPENINGS*

REGULATIONS FOR THE PROTECTION (CLASS A) OF OPENINGS IN DIVISION WALLS BETWEEN SEPARATE BUILDINGS OR SECTIONS OF BUILDINGS

The great importance of fire walls as a safeguard to life and in preventing the spread of fire, and the fact that they are liable to be severely exposed to fire for considerable periods, makes it essential that all openings in such walls be protected by the most efficient methods. Only such fire retardants are included in this class as have been shown by experience and tests to furnish a high degree of fire protection when installed on both sides of the wall, and if used as exit doors, to offer no serious accident hazard under normal or emergency conditions in this situation.

General Regulations

1 and 2. NUMBER SIZE OF WALL OPENINGS.—The number and size of openings in fire walls should be proportionate to the number of occupants who may have to use the openings as a means of exit at time of fire. It is important that openings in fire walls be as small as the circumstances will permit; they should not exceed 80 square feet, except in some cases for the ground floor, where wagons, etc., must be passed through. Generally speaking, the openings should be as remote from each other as possible. From the fire protection viewpoint, the number of openings should be as few as possible, as there is always the chance that fire doors will be open at time of fire, either through neglect to close them, failure of the automatic closing devices, or inability to close doors that have been opened to afford better opportunity for fighting fire. For these reasons openings found to be unnecessary should be closed with masonry well bonded in.

3. NUMBER OF DOORS.—Each side of the wall at every opening in an interior fire wall to be provided with an approved self-closing or automatic fire door, except openings in enclosing walls to fireproof rooms separating specially hazardous processes from the remainder of the building may be provided with doors on one side of the wall.

NOTE.—Self-closing doors are normally closed doors, which, when opened, will close and latch or lock. Automatic doors are doors arranged to close when released by the action of heat.

4. MASONRY AT WALL OPENINGS.—(a) Walls to be plumb and true, and present smooth masonry surfaces without any wood or combustible trim at openings.

(b) Where swinging tin-clad fire doors shut into a brick rabbet in wall, rabbet to be at least 3 x 4 inches, and to have true sides and angles so that door will close snugly.

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* Regulations of the National Board of Fire Underwriters, issued in 1915. Illustrations are reproduced from original cuts by permission of the National Board.

5. **SILLS.**—On account of the number of methods specified, inspection departments having jurisdiction should be consulted before the installation of sills.

(a) Concrete for sills to be made of one part Portland cement, two parts clean sharp sand, and four parts clean broken stone which will pass through ⅝-inch mesh. To be thoroughly mixed, well tamped and finished smooth and flush with the upper surface of the sill. Concrete to be a wet mixture.

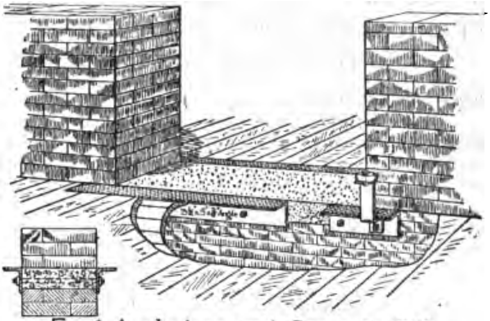

Fig. 1. Angle Iron and Concrete Sill.

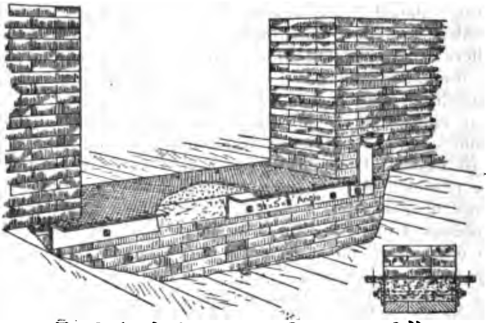

Fig. 2. Angle Iron and Concrete Sill, with Plate on Top.

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(b) To be of concrete not less than 4 inches in thickness, and placed between a 3½ x 5 x ⅝-inch steel angle on each side of the wall. Angles to extend at least 6 inches past the opening on each side. Long side of angles to rest against the face of the wall, and short side to extend out under the bottom of the door. Upper face of angles to be covered with a tread having an anti-slip surface flush with the floor and sill. Angles to be fastened together through the wall by ¾-inch bolts placed close to each side of the wall opening, and not to exceed 18 inches apart at any point. Bolts to have nuts at each end. See Figure 1.

NOTE.—Where sliding fire doors are used, the upper face of the angle should be notched out at one end on each side of the wall, or angles drilled, and ⅝-inch bolts installed so as to permit the proper installation of the stay roll for holding the door in position. In new buildings this should be done before the angles are installed.

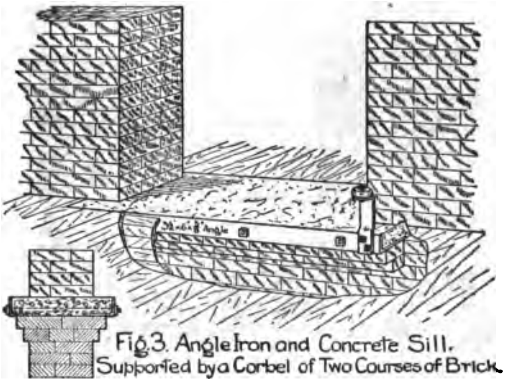

Fig. 3. Angle Iron and Concrete Sill. Supported by a Corbel of Two Courses of Brick.

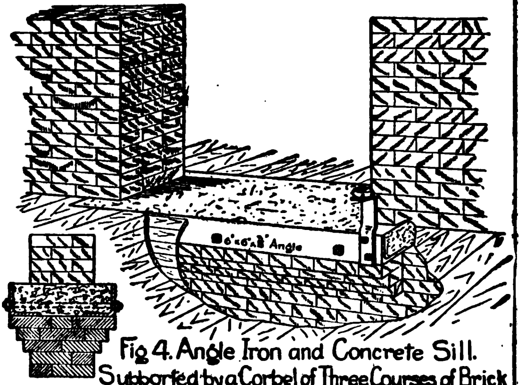

Fig. 4. Angle Iron and Concrete Sill. Supported by a Corbel of Three Courses of Brick

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Where the wall is rabbeted for a swinging fire door, a steel plate not less than ⅜-inch thick and 5 inches wide may be used in place of the steel angle on that side of the wall, or the steel angle may be installed so that the short side extends into the wall.

(c) To be constructed as specified in Rule b and covered with a tread having an anti-slip surface extending out flush with the outer edges of the angles on each side of the wall and held securely in position by ⅜-inch counter sunk machine screws spaced not to exceed 9 inches apart. See Figure 2.

(d) To be of concrete not less than 3½ inches in thickness and placed between a 3½ x 6 x ⅜ inch steel angle on each side of the wall. Angles to extend at least 6 inches past the opening on each side. The short side of the angle to be parallel with and set out 4 inches from the face of the wall. The long side of the angle to extend into the wall. Angles to be fastened together through the wall as specified in Rule 5b.

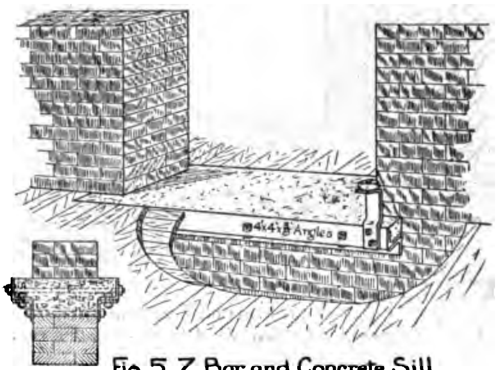

Fig. 5. Z Bar and Concrete Sill

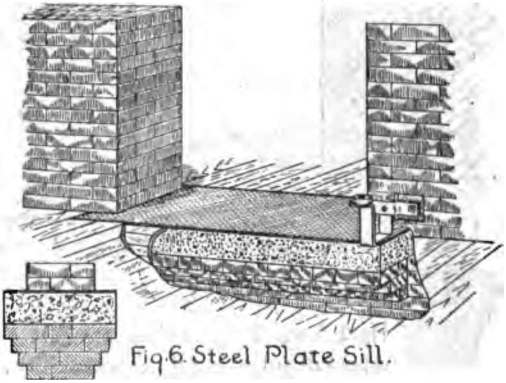

Fig. 6. Steel Plate Sill.

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In new walls, two courses of brick work to be corbeled out to support the angles, the upper course to be 1½ inches back from the perpendicular face of the angle. See Figure 3.

Where a large amount of heavy trucking is done, the concrete should be at least 6 inches in thickness, the steel increased proportionately, and three courses of the brick corbeled out to the outer edges of the sill. See Figure 4.

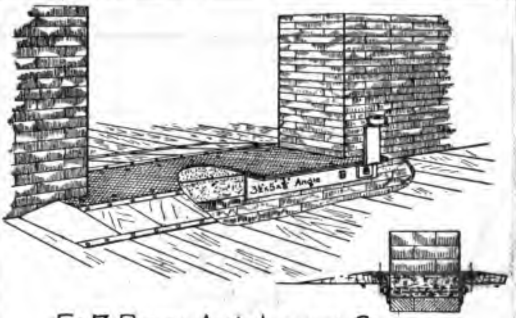

Fig. 7. Raised Angle Iron and Concrete Sill with Inclines.

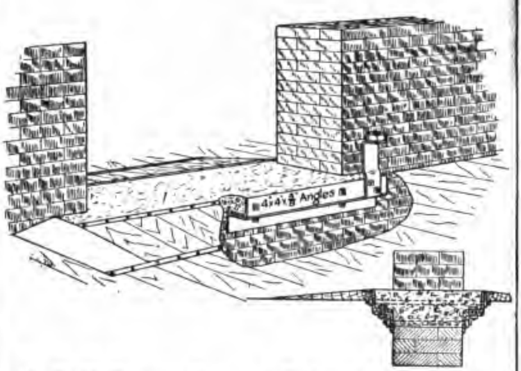

Fig. 8. Z Bar and Concrete Sill with Inclines.

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In old walls Z-bars made of two 4-inch angles ⅜ inch thick bolted together or equivalent solid Z-bars may be used in place of the steel angles and corbeling. The concrete to be not less than 7 inches in thickness, and the Z-bars fastened together by ¾-inch wall bolts through both perpendicular faces. See Figure 5.

NOTE.—When sliding fire doors are used the angles or Z-bars should be drilled and 5/8-inch bolts installed so as to permit the proper installation of standard stay roll for holding the door in position. In new buildings this should be done before the steel work is placed in the sill.

Where the wall is rabbeted for a swinging fire door, a steel plate not less than 3/8 inch thick and 8 inches wide may be used in place of the angles or Z-bars.

(e) To consist of an iron or steel plate having an anti-slip surface securely attached to concrete support not less than 6 inches thick. Concrete support to be built into wall at least 6 inches on each side of the opening and extend under and flush with the outer surface of the door. Three courses of the brick work under sill to be corbeled out flush with the outer surface on each side of the wall. See Figure 6.

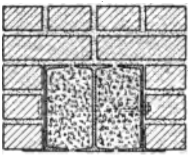

Fig. 9
Steel Lintel

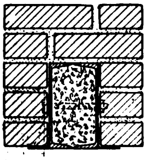

Fig. 10
Steel Lintel

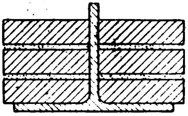

Fig. 11
Cast Iron Lintel

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NOTE.—Where sliding fire doors are used, the plate should be notched out at one end and on each side of the wall so as to permit the proper installation of the stay roll for holding the door in position. In new buildings this should be done before the tread is installed.

(f) To be constructed in accordance with any of the above methods raised 1½ to 2 inches above the surface of the floor and provided with inclines on each side, and at each end having a pitch not more than 1 inch vertical to 6 inches horizontal.

NOTE.—Raised sills are of advantage in preventing water from running through the door openings at time of fire, but offer an appreciable accident hazard and should, therefore, be avoided at openings used as exits.

(g) To consist of an iron or steel plate having an anti-slip surface raised 2 inches above the surface of the floor and extended out flush with the face of the wall on each side. Plate to be attached to a 3 x 4 x ⅜ inch steel angle on each side of the wall by ⅜-inch machine screws spaced not exceeding 9 inches. Ends of angles to be securely attached to steel wall frame. Angles to be fastened together through the wall by ¾-inch bolts spaced not exceeding 18 inches. Space between wall and sill plate to be filled solid with concrete or cement grout. See Figures 14, 28, 29 and 30.

NOTE.—This sill is designed for solid steel fire doors where a raised sill is required. The channel for sliding doors is bolted or riveted to the sill angles on each side of the wall.

6. LINTELS.—A brick arch is preferable, but lintels made of steel, cast iron or reinforced concrete may be used if constructed as specified in the following rules. Stone or tin-clad wooden lintels are prohibited.

(a) To be of standard steel sections securely riveted or bolted together, protected by at least 4 inches of solid brickwork flush with the face of the wall on each side and provided with a full header course of brick just above the steel work. Spaces between sections to be filled solid with brickwork, concrete or grout. See Figures 9 and 10.

(b) To be of cast-iron tee sections not less than 1 inch in thickness, protected by not less than 4 inches of solid brickwork flush with the face of the wall on each side. See Figure 11.

(c) To be of solid reinforced concrete the full thickness of the wall. Reinforcing members to be protected by at least 1½ inches of concrete on exposed faces.

7. WALL FRAMES.—Steel wall frames are of particular value where swinging tin-clad doors are mounted flush with the face of the wall, and for mounting steel fire doors. They provide for a tight-fitting door, serve to protect the brickwork from injury, furnish a secure fastening for the hardware, and are neat in appearance. Where used they should be constructed and installed in accordance with the following rules:—

(a) Frames for tin-clad doors to be made of 3½ x 3½ x ¼ inch steel angles at the sides and top of the opening on each side of the wall. Angles to be riveted together at upper corners, to extend into the sill at least 2 inches, to be bolted in position by ¾-inch bolts spaced not exceeding 24 inches, and provided with ¾ x ½ inch stops attached by ⅜-inch rivets spaced not exceeding 12 inches. Catches for the latches and the pin blocks to receive the hinges to be of heavy steel and properly riveted to the frame by at least two ⅜-inch rivets. See Figure 12.

(b) Frames for tin-clad doors to be made of 3 x 3 x ¼ inch steel angles set into rabbets in the brickwork at sides and top on each side of the wall. Angles to be riveted together at upper corners, to extend into the sill at least 2 inches and to be fastened in position by 1¼ x ¼ inch bars spaced not exceeding 24 inches apart all around. Bars to be fastened to angles by two ⅝-inch countersunk rivets or bolts at each end. Catches for the latches and hinge pins or pin blocks to be of heavy steel properly riveted to the frame by at least two ⅝-inch rivets. See Figure 13.

NOTE.—Where the frames are mounted during the construction of the wall the connecting bars should be attached to the legs of the angles to which the catches and pin blocks are attached.

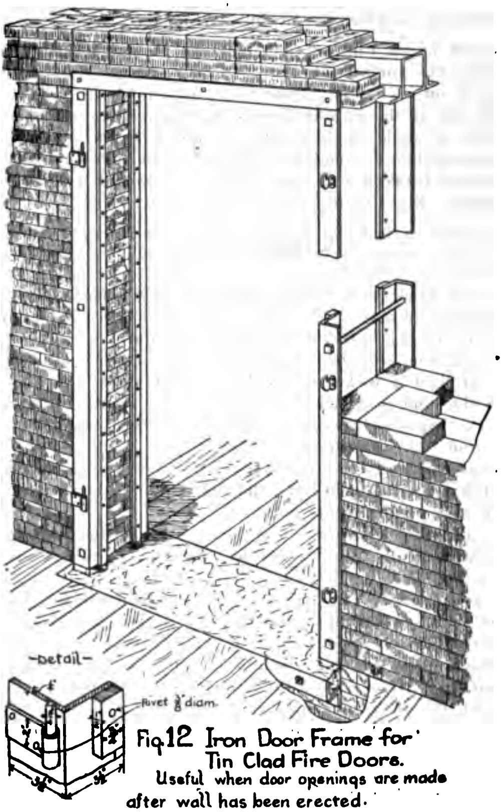

Fig. 12 Iron Door Frame for Tin Clad Fire Doors. Useful when door openings are made after wall has been erected.

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(c) Frame for solid steel doors to be made of 4 x 3 x ⅝ inch steel angles at the sides and top of the opening on each side of the wall. Angles to be riveted together at upper corners, to extend into the sill at least 2 inches, and to be fastened in position by 1¼ x ¼ inch bars spaced not exceeding 24 inches apart all around. Bars to be fastened to angles by two ⅝-inch countersunk rivets or bolts at each end. Catches for the latches, hinge pins or hinge blocks, and binders for sliding doors to be of heavy steel properly riveted to the frame by at least two ⅝-inch rivets. See Figure 14.

NOTE.—The thickness of the wall should be accurately measured so that the bars fastening the wall frame together can be cut to exact length. Where sliding doors having channels at the bottom, or swinging doors having raised sills are used, the wall frame should be securely attached to the sill angles as specified in Rule 5g. Channels for sliding doors to be riveted or bolted to the sill angles.

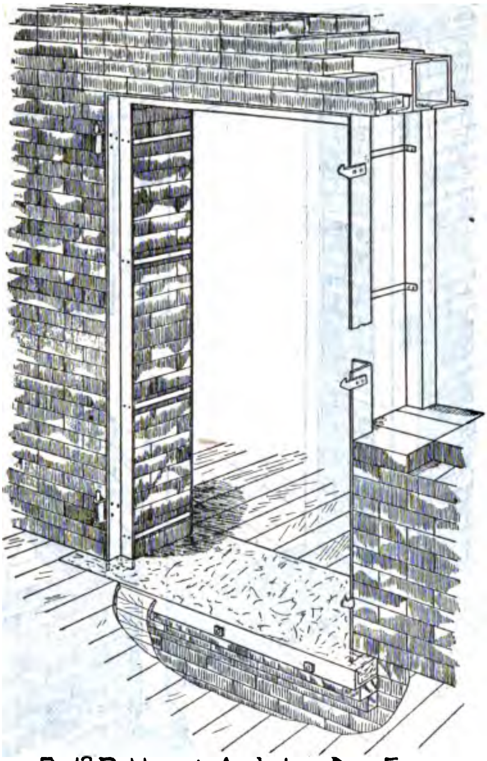

Fig. 13 Rabbeted Angle Iron Door Frame, for Tin Clad Fire Doors.

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(d) Wall frame used to protect the brickwork from injury to be made of 4 x 4 x ⅜ or 4 x 4 x ½ inch steel angles at sides and top of the opening on each side of the wall. Frames to be held in position as described in Rule 7c or provided with plate fillers on the face of the jambs securely riveted to the angles on each side of the wall.

NOTE.—Angles extending only part way up on the sides of the wall opening prevent the fire doors from forming a tight closure at the upper portion of the wall opening and are prohibited.

8. **MEASUREMENTS FOR SIZE OF FIRE DOORS.**—Openings in walls to be carefully measured before the doors are built. Where wall frames are not used, the measurements to be from the edges of the brickwork, irrespective of any steel work in the opening. Where wall frames are employed, the size of the door is determined by the size of the opening in the frame.

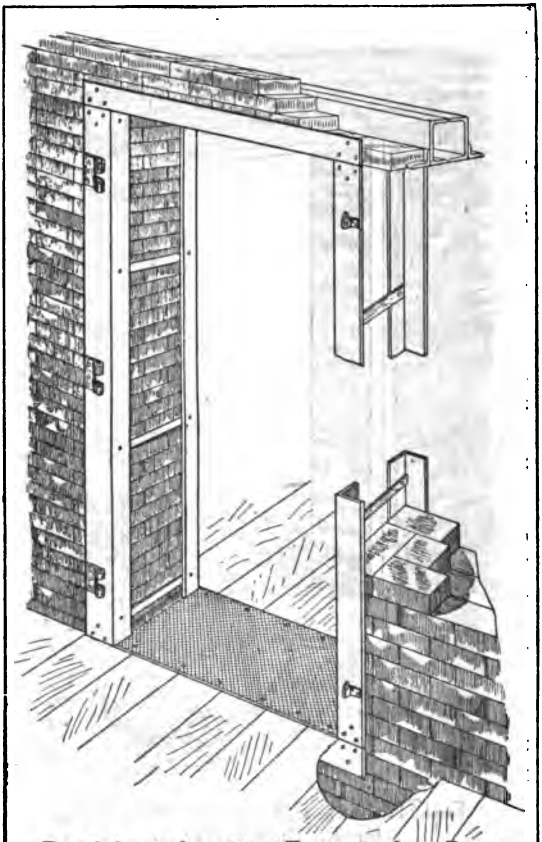

Fig. 14 Angle Iron Wall Frame for Iron Doors

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9. **SLIDING FIRE DOORS.**—Doors of this type to be employed unless features relating to exit facilities, service requirements, location or installation make other types preferable.

NOTE.—Sliding fire doors can be mounted close to the wall, require only a small amount of floor space, are less likely than many other types to be rendered inoperative by obstructions. They can be counterbalanced so as to be operated without great difficulty and can be made to close automatically without the use of complicated apparatus. They are particularly suitable for large opening, but the method of operating them is not as obvious as that of swinging doors, and they are more subject to injury from falling materials at times of fire than doors that close flush with the face of the wall. They can be used only where there is sufficient wall space at the side of the wall opening.

10. SWINGING FIRE DOORS.—Doors of this type may be employed where the character and size of the opening make the use of this type of door advisable. Where egress is in one direction only the doors should open in the direction of travel.

NOTE.—Where egress is in one direction only, swinging doors are easier to operate than any other type of door, especially under emergency conditions. Swinging fire doors require considerable clear floor space, are more liable to be rendered inoperative by obstructions than sliding fire doors, and are difficult to make automatic without the use of complicated apparatus. Swinging doors in pairs do not furnish as satisfactory protection against fire as single doors.

11. VERTICAL DOORS.—Doors of this type may be employed where horizontally sliding or swinging doors cannot be used, and where the doors do not serve as exit doors at time of fire.

NOTE.—Vertical doors require considerable head room above the door opening and must be counterweighted to render them operative. They can be made automatic without the use of complicated apparatus. They are difficult to operate, especially after they have closed automatically, and their use in any given case should be considered in its relation to effect upon hazard to life.

12. ROLLING STEEL FIRE DOORS.—Doors of this type may be employed where the transmission of heat through the doors is not liable to result in the spread of fire, and where the doors do not serve as exit doors at time of fire.

NOTE.—Rolling doors are capable of being installed in locations where space limitations prevent the installation of other types of doors. They can be mounted flush with the face of the wall so that no floor space is required, and are less likely than many other types to be rendered inoperative by obstructions. They can be counterbalanced so as to operate without great difficulty, but the method of operating them is not as obvious as that of other types of doors, and some types of rolling doors are difficult to operate after they have closed automatically. The type and use of these doors in any given case should be considered in its relation upon hazard to life.

13. NORMALLY CLOSED DOORS.—To be arranged to close by gravity, or equipped with an approved door check or device to insure proper closing after the door has been opened.

14. AUTOMATIC DOORS.—To be operated by at least one approved releasing device above the door and close to the ceiling. Where desired the door may be also arranged to close by the operation of an additional releasing device near the top of the door opening.

15. OPENINGS FOR SHAFTING.—Where a shaft passes through a fire wall, the hanger to be placed on one side of the wall, and the opening around the shaft bricked up as closely as possible without touching the shaft. The remaining space around the shaft to be finished with cement mortar, leaving a hole one inch larger in diameter than the shaft and concentric with the shaft.

NOTE.—In some cases it may be necessary to place a hanger on each side of the wall. The space around the shaft permits adjustment and insures clearance between shaft and wall.

16. OPENINGS FOR BELTS.—To be protected by two approved sliding doors coming together in the middle of the opening through the wall. Doors to

slide in approved upper and lower guard rails or channels retaining them in place, and be provided with suitable fastenings for holding them together in the closed position. Guard rails to be long enough to retain the doors when open, and secured by ¾-inch bolts through the wall.

See Figure 34 showing tin-clad doors used for this purpose.

NOTE.—Care is necessary to see that the slots are of sufficient size to insure free and unobstructed belt travel. The dimensions of the slots will vary considerably with the size of the belt, length of span, tightness of belt, presence or absence of guide rolls and other local conditions.

17. CARE AND MAINTENANCE.—(a) Fire doors should be ready for instant use at all times, therefore it is necessary to keep the surroundings clear of everything that would be likely to obstruct or interfere with their free operation. They should be kept closed and fastened nights, Sundays and holidays, and whenever the openings are not in use.

(b) Never tack any tin on a tin-clad door. When tin becomes worn substitute new sheets in the same manner as when covering a new door. Damaged parts of other types of fire doors should be replaced by new parts.

(c) The following notice should be posted at each opening protected by fire doors, preferably stenciled on each side of the fire door itself, "Keep This Fire Door Shut."

(d) Doors of the sliding pattern should be stenciled on both sides with the words "To Open," and an arrow indicating the direction. Swinging doors should be stenciled, "Turn Knob and Push" (or pull), or "Press Down Lever and Push" (or pull), as the case may be.

18. PAINTING FIRE DOORS.—(a) Solid steel doors and rolling steel doors to be given one good coat of paint before they leave the shop and one coat after installation. Rolling steel doors not to be opened (coiled up) until the paint has dried sufficiently to prevent adhesion between the parts. Paint to be satisfactory to inspection departments having jurisdiction.

NOTE.—Where possible, both coats of paint should be applied to steel rolling doors before they are erected.

(b) When subject to rapid deterioration as a result of corrosion, tin-clad and sheet metal doors to be given at least two good coats of paint which is satisfactory to inspection departments having jurisdiction.

NOTE.—Doors of this type do not require painting where they are used in clean, dry localities.

Tin-Clad Fire Doors

GENERAL

Standard tin-clad fire doors are fairly substantial in construction, practical under most conditions, and easy to install. Doors on both sides of the wall furnish a high degree of resistance to fire and to the transmission of heat for long period of exposure, and resist fire streams well. Under adverse conditions of service they are liable to deteriorate rapidly and are difficult to maintain.

19. VENT HOLE.—Cut a hole 4 inches in diameter through the middle plate on the exposed side of the door, but not through the wood core. Secure the tin around this opening with small nails, and thoroughly paint the wood thus exposed. See Figure 19.

NOTE.—The hole will prevent excessive bulging of the tin covering and rupture of the joints between the plates by permitting the escape of gases generated from the wood core when the door is exposed to fire. Care should be taken to ascertain which is the exposed side of the door before the hole is made. Usually the hole should be made after the door is mounted.

20. **MOUNTING TIN-CLAD DOORS.**—The doors should be completely tinned before the hardware is attached, and only such hardware as has been found satisfactory after examination and test, should be used. (See list of approved hardware.)

Read all of the rules for mounting before starting.

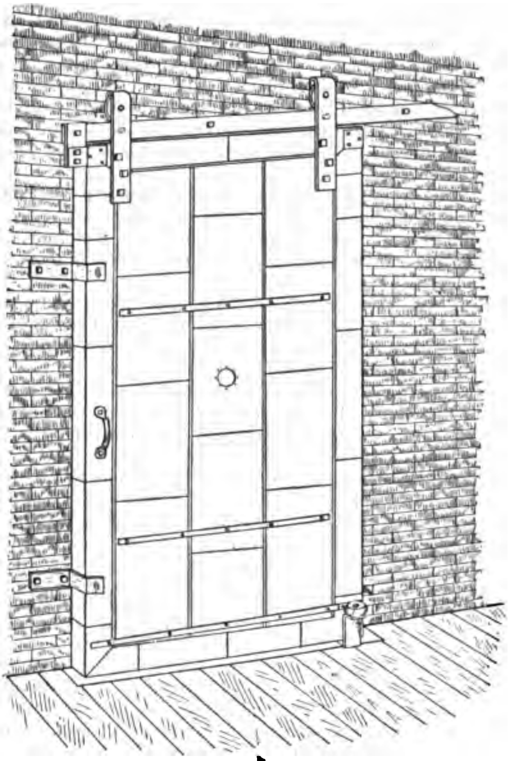

Fig. 15. Door Closed Properly Hung.

One track bolt under each hanger

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SLIDING TIN-CLAD DOORS

21. **SIZE AND SHAPE OF DOORS.**—Doors to overlap sides and top of wall opening 4 inches. Where steel lintels are used doors to overlap the brickwork 4 inches above upper edge of steel unless such lintels are fireproofed in a manner satisfactory to the inspection department having jurisdiction. Top of door to conform to incline of track, ¾ inch to one foot.

22. **MOUNTING SLIDING DOORS.**—(a) Mounting Track.—Length of track to be equal to twice the width of the wall opening plus 21 inches.

Wall bolts to be so spaced that one bolt will be located directly opposite each hanger when the door is closed, and so that front and back bumpers can be attached. Holes to be 13/16 inch in diameter.

NOTE.—Doors for openings in excess of 6 feet in width require three hangers.

Track to have an incline of ¾ inch to one foot when mounted.

Place door in proper position over opening with ⅜ inch of blocking between sill and bottom, and ¼-inch strip on upper edge of door. Place track in exact position over door, and carefully mark circles on wall at holes for track bolts. Mark long crosses through circles after track has been removed so that centers of holes can be maintained, and carefully drill holes through wall. Bolt track in the position first marked, placing a wall bracket at each bolt. The front and back bumpers should also be installed when the track is bolted in position.

Never attach track to wood frame, even if frame is tin-clad, and never use wood or lead plugs in the wall to support wall bolts.

(b) Attaching Hangers.—Doors for openings six feet and less in width to be provided with two hangers. Doors for openings in excess of six feet to have three hangers.

Place hangers on track directly opposite wall bolts, and carefully mark location of bolt holes on door. Bore holes exactly where marked, and bolt hangers to door, using ½-inch special countersunk carriage bolts, and placing heads of bolts on the back of the door.

Remove blocking from under door and from between door and track.

(c) Attaching Binders.—Two binders are required, the upper binder to be placed about 24 inches from the top of the door, and the lower binder about 18 inches above the sill.

When the door is in contact with the front bumper place the binders in contact with the edge of the door so that it will strike both binders and bumper in closing, and mark and drill the wall as described for track bolts. Bolts for fastening the binders to be ¾ inch in diameter, and extended through the wall. See Figure 15.

NOTE.—Care should be taken not to make the bolt holes unnecessarily large. In some cases it may be advisable to set the binders in cement when they are bolted to the wall. A mixture of one-half clean, sharp sand and one-half Portland cement is recommended for this purpose.

(d) Attaching Stay Roll.—Chip out brickwork carefully, so that the stay roll will be flush with the surface of wall and sill, and carefully mark and drill wall for through bolt and eye bolt at the side of the door opening. Set the parts with cement, if necessary, and bolt firmly to wall. When the door is closed adjust the roller against the wedge at the end of the chafing strip so that the door will be held close to, but not tightly, against the wall. See Figure 16.

NOTE.—The brickwork should be chipped out, and the stay roll fitted to the wall before the door is in position. It can then be more easily installed after the door is hung. Where stay rolls are bolted together through the wall see last part of Rule a. The stay rolls shown in Figures 1, 2, 3, 4, 5, 7, 8 and 17 are bolted to the steel work of the sill, and are recommended for new work.

(e) Attaching Chafing Strips.—Three chafing strips required. Two half oval strips on the back of the door, with flat companion strips on the front of the door, and one flat strip on the front of the door near the bottom.

Strips on the back of the door to be placed one third the distance from the top and about 24 inches from the bottom. Length of the strips to be 4 inches less than the door opening. Strips to be parallel with the door track and bolted through the door to the flat strips on the front of the door with ¼-inch bolts spaced, not exceeding 9 inches, placing the end bolt one inch from the ends of the strips. See Figures 18, 19 and 15.

Strip on the front of the door to be parallel with the door track and so placed as to take the wear of the stay roller. To be 5 inches less than the width of the door and fastened to the door by 1¼-inch wood screws, spaced not exceeding 12 inches apart. See Figures 19 and 15.

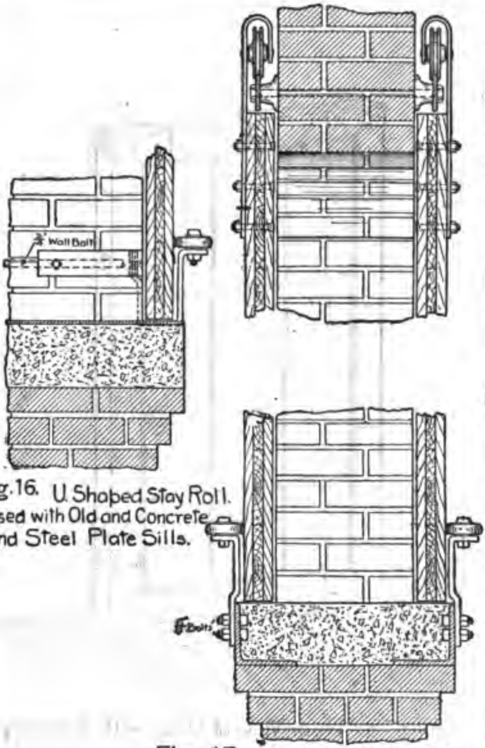

Fig. 16. U Shaped Stay Roll. Used with Old and Concrete and Steel Plate Sills.

Fig. 17. Opening Protected by Standard Double Sliding Doors Mounted with Standard Hardware.

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(f) Attaching Wedge.—To be placed back of the stay roll when the door is closed, and to be fastened to the door by one 1¼-inch and one 2-inch wood screw. See Figure 19.

(g) Attaching Bumper Shoes.—Four necessary, one opposite each bumper and one opposite each binder. To be fastened to the edges of the door by 1¼-inch wood screws. See Figures 18 and 19.

NOTE.—The front and back bumpers are mounted with the track. See Rule 22a.

(h) Attaching Handles.—Flush pull on the back of the door to be countersunk flush with the surface of the door. Heavy, bow-shaped handle to be attached to front of door. Handles to be bolted together through the door or otherwise securely attached. See Figures 18, 19 and 15.

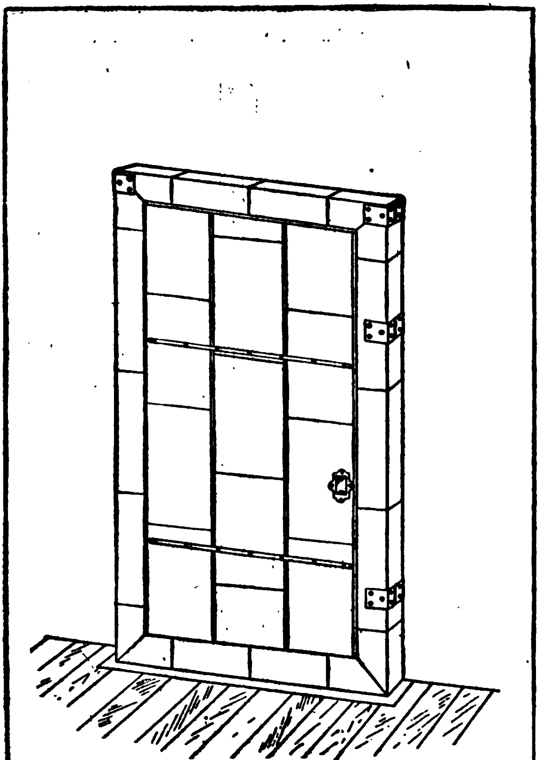

Fig. 18. Rear View of Door with Trimmings.

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(i) Bolts and Washers.—Bolts for track, binders and stay roll to be ¾ inch in diameter, to extend through the wall, and to be provided with washers 4 inches in diameter on opposite side of the wall. See Figures 15 and 17.

NOTE.—Where the above members are bolted together through the wall the washers are unnecessary.
Use ⅝-inch bolts in attaching stay roll shown in Figures 1, 2, 3, 4, 5, 7, 8 and 17 to the steel work of the sill.

(j) Operation of Door.—The door should hang and operate freely. If the wall is unusually rough and uneven it may be necessary to dress it off, so as to remove all obstructions and prevent the destruction of the tin covering by chafing. The introduction of thin plates (1/16 to ⅛ inch) between the wall and brackets on the portion of the track at the side of the opening will sometimes remedy the defects due to slight unevenness in the wall.

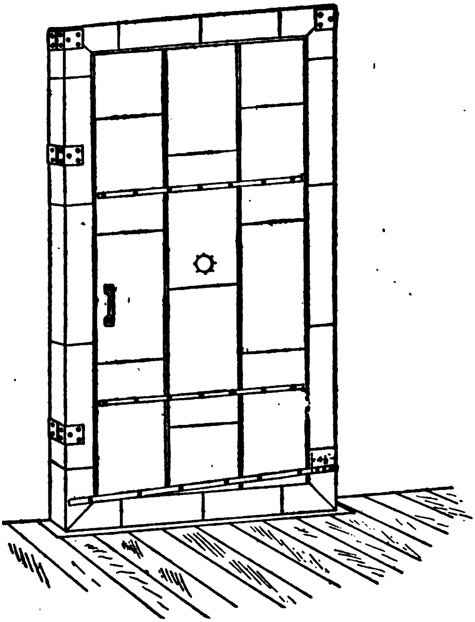

Fig. 19. Front View of Door with Trimmings.

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The holes for the track bolts should be drilled with sufficient accuracy so that the door will not sag and chafe on the sill. If the door does sag, substantial metal strips should be installed under the track bolts so as to raise the door sufficiently to prevent chafing. Short length of ¾-inch gas pipe around the track bolts will often remedy this defect.

(k) Slatted Framework.—When necessary, a framework of slats should be built outside of sliding doors to prevent piling of stock, etc., against them.

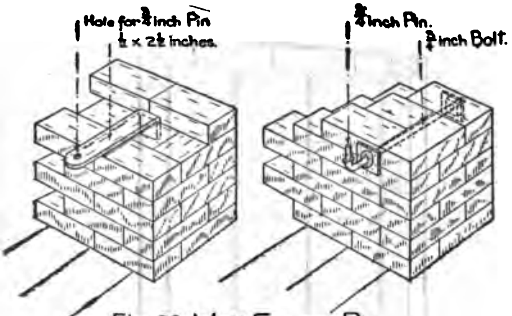

Fig 20. Wall Eye and Pin

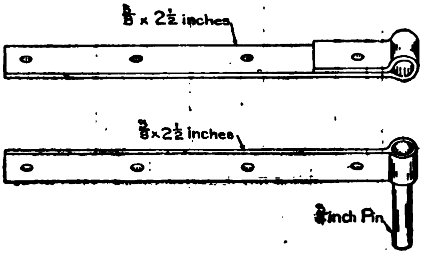

Fig. 21. Hinges with Eye or Pin.

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(l) Protection of Covering.—When the front edge of door is liable to injury from trucks, etc., a continuous U-shaped strip made of No. 14 U. S. gauge steel, and extending high enough to prevent injury, should be installed. Strips should lap the sides of the door 4 to 6 inches and should be fastened on by 1¼-inch wood screws on each side of the door, spaced not exceeding 12 inches apart and staggered. The above strip will render the lower bumper shoe unnecessary.

SWINGING TIN-CLAD DOORS

23. SIZE AND SHAPE OF DOORS.—Doors to shut into rabbet in wall, into approved wall frame, or, when acceptable to inspection departments having jurisdiction, doors may overlap sides and top of wall openings as required for sliding doors. See Rules 4, 7, a, b, d, 8 and 10.

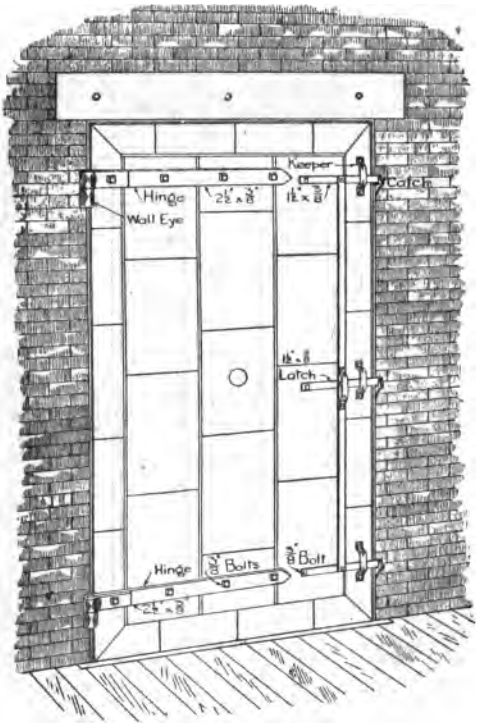

Fig. 22 Swinging Door in Rabbeted Frame

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24. MOUNTING SINGLE SWINGING DOORS.—(a) Attachment of Wall Eyes, Wall Pins and Catches.—To be built in the wall, bolted through the wall with ¾-inch bolts with 3/16-inch steel washers on each side of wall, or to be securely fastened to approved steel wall frames. See Figures 12, 13, 20, 21, 22 and 23.

(b) Attachment of Hinges.—Doors in excess of 7 feet in height or 6 feet in width to be provided with three hinges.

Place door in proper position at wall openings, with ¼-inch blocking between bottom of door and sill on hinge side and ½-inch blocking on lock side. Place hinges in exact position on door and carefully mark location of bolt holes on door. Bore holes exactly where marked and bolt hinges to door using ⅜-inch carriage bolts or machine bolts with washers under heads on the back of the door. Nuts to bear against the hinges.

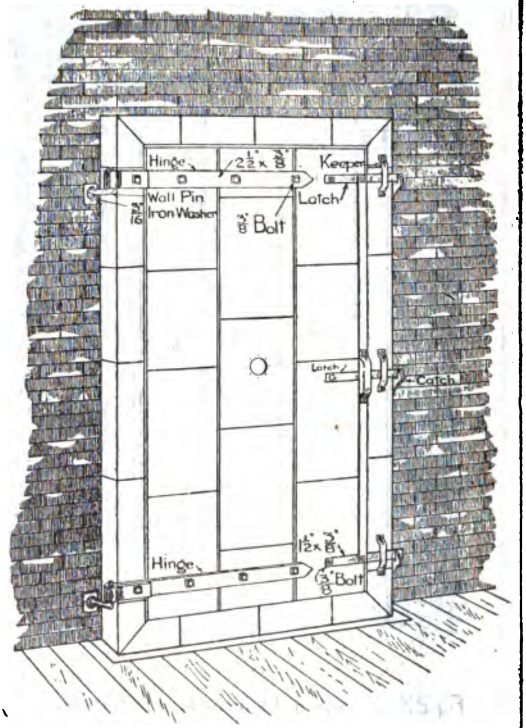

Fig. 23 Swinging Door without Rabbet in wall.

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Remove blocking and see that door opens and closes properly.

(c) Attaching Latches.—Doors in excess of 5 feet in height, to be provided with at least three latches working together. Upper and lower latches to be spaced not to exceed 12 inches from top and bottom of door opening.

Latches to be operated from either side of door and so as not to interfere with the hinges. See Figures 22 and 23.

Place latches in exact position on door with latches in catches, and with connecting bar adjusted for expansion allowances. Carefully mark location of bolt holes for operating handle and pivot plates. Bore holes exactly where marked and bolt latches to door, using ⅜-inch machine bolts with bearing plates on back of door. Attach operating handle.

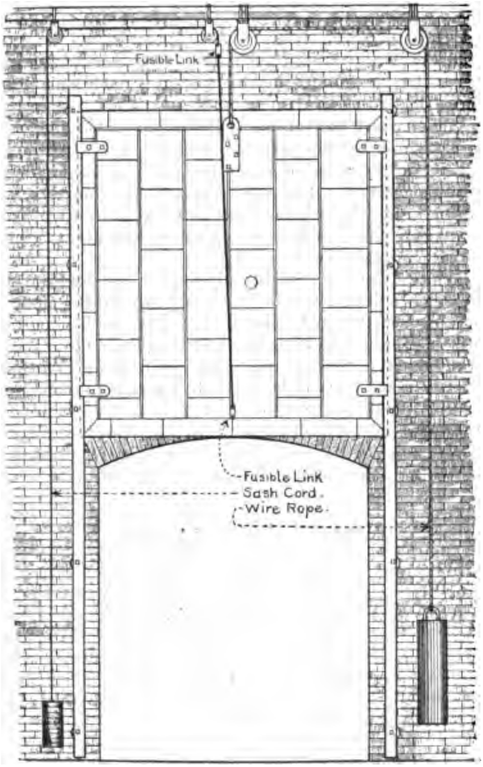

Fig. 24 Vertical Balance Automatic Door

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NOTE.—The bar connecting the latches should be adjusted so that it will not lift the latches by expansion when heated.

Place keepers in position over latches making allowance for the movement of the latches. Mark location of bolt holes on door, bore holes and bolt keepers to door, using ⅜-inch machine bolts with bearing plates on back of door. See Figures 22 and 23.

NOTE.—Where the door is mounted on the face of the wall, the keepers should be placed about 5 inches back from the edge of the door, so that the plates and bolt heads on the back of the door will not be in contact with the wall when the door is closed.

Attach spring to prevent rebound of latches and insure latching when door is slammed.

NOTE.—The destruction of the spring at time of fire does not affect the reliability of the hardware.

(d) Operation of Door. The door should swing easily and freely on its hinges. The latches should operate freely on their pivots and ride up the inclines on the catches and snap into position when the door is slammed shut or closed with moderate force.

25. MOUNTING SWINGING DOORS IN PAIRS.—The rules for mounting single doors apply to doors in pairs with the following additions.

(a) Attaching Door Bolts.—The standing door of the pair to be provided with a ⅞-inch steel bolt at top and bottom. Both bolts to enter substantial strike plates or catches securely fastened into arch and sill.

Place door bolts in exact position on the back of the door and carefully mark location of bolt holes. Bore holes exactly where marked and bolt door bolts to the door, using ⅝-inch machine bolts with bearing plates on front of the door. Where door bolts are operated together, the handle to be bolted in position through the door.

With the standing door in the closed position, carefully mark the position where the door bolts strike the head and sill of the door opening and securely anchor or bolt the strike plates or catches in exact position.

(b) Attaching Catches.—With both doors closed, place the catches in exact position under the latches and mark position of bolt holes on door. Bore holes exactly where marked and bolt catches to door, using ⅝-inch machine bolts and plates on back of door.

(c) Attaching Astragal.—Place astragal in exact position on edge of door, mark position of bolt holes, bore holes and bolt to door, using ⅝-inch machine bolts, with washers under heads on back of door.

VERTICAL TIN-CLAD DOORS

26. SIZE AND SHAPE OF DOORS.—Doors to overlap sides and top of wall opening 4 inches. When steel lintels are used, doors to overlap brickwork 4 inches above upper edge of steel, unless such lintels are fireproofed in a manner satisfactory to the inspection department having jurisdiction.

27. MOUNTING VERTICAL DOORS.—(a) Mounting Guides.—Place door in proper position over opening with side edges plumb. Place guides in exact position with ⅝-inch strip between door and guide on each side. Carefully mark circles on wall at holes for wall bolts, remove guides and carefully drill holes through wall. Replace guides and bolt to wall with ¾-inch bolts, placing 4-inch washers on the back of the wall. Remove spacing strips. See Figure 24.

(b) Attachments to Door.—Place attachments in exact position on door and carefully mark location of bolt holes. Bore holes exactly where marked and bolt each piece to door, using plates or washers on back of door. See Figure 24.

(c) Pulleys and Counterweight.—Attach pulleys for counterweight cable securely in position above door, attach the wire cable and permanent counterweight. See Figure 24.

(d) Automatic Device.—Attach pulleys for auxiliary counterweight securely in position above door, attach cord to bottom of door and install auxiliary counterweights, placing a fusible link in the cord near the bottom of the door and also near the ceiling when the door is open. See Figure 24.

Solid Steel Fire Doors

GENERAL

Standard solid steel fire doors are substantial in construction and practicable under most conditions. Doors on both sides of wall furnish a high degree of resistance to fire and a fairly high resistance to the transmission of heat for long periods of exposure and resist fire streams well. They are durable and easy to inspect and maintain, but are somewhat difficult to install.

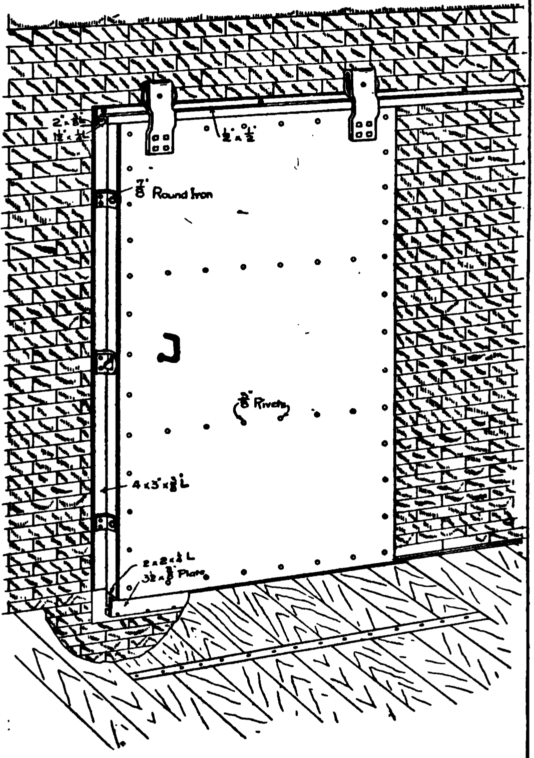

Fig. 25 Sliding Iron Door, Closed.

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28. SETTING WALL FRAMES.—Solid steel fire doors to be mounted on steel wall frames, which should be set perfectly level and plumb and bricked into

the wall. If the frame is installed in an old wall, the opening should be cut larger than the frame and the brickwork built up to the frame and well bonded to the wall, using cement mortar and thoroughly painting up around the frame. See Rule 7c for the construction of wall frame.

SLIDING SOLID STEEL DOORS

29. SIZE OF DOORS.—Doors in excess of 4 feet in width to overlap the sides of wall frame at least 2 inches and at least 1 inch at top. Angle at bottom of door to extend at least 1 inch into groove at sill. The angle at bottom of door and groove in sill may be omitted for doors 4 feet and less in width. See Figures 25, 26, 27 and 28.

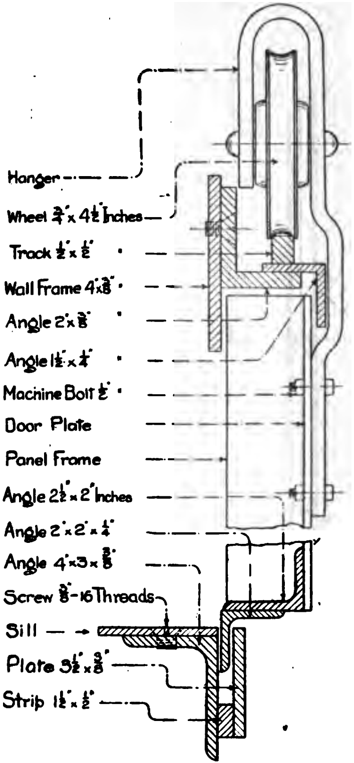

Fig 26 Detail Showing Hanger and Top and Bottom Channels for Sliding Iron Doors

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30. **TOP AND BOTTOM CHANNELS.**—(a) Doors in excess of 4 feet in width to operate in channels or grooves at top and bottom. The groove at bottom may be omitted for doors 4 feet and less in width. Length of upper channel to be equal to twice the width of the opening in the wall frame plus 8 inches. Upper channel to be provided with a ½ x ½ inch steel strip to serve as a track for the wheels of the door hangers. Lower channel or groove, where used, to extend beyond the wall frame at least 12 inches on the side toward which the door opens. See Figures 25 and 26.

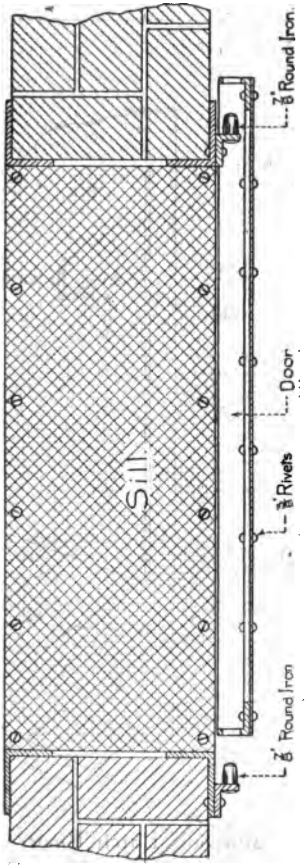

Fig. 27 Horizontal Section of Sliding Iron Door. Showing Position of Lugs or Binders.

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(b) Upper and lower channels to be attached to wall frame by ⅝-inch rivets or bolts spaced not exceeding 12 inches. Upper channels to be attached to wall by ¾-inch bolts spaced not exceeding 14 inches.

31. MOUNTING SLIDING DOORS.—(a) After the wall frame is set, place the upper and lower channels in position and bolt them to the frame. Carefully mark circles on wall at holes in upper channel for wall bolts. / Remove upper channel and mark long crosses through circles so that centers of holes can be maintained, and carefully drill holes through wall. Place the door in proper position over opening with ¼-inch blocking between sill and bottom of door. Place upper channel in position under the hanger wheels and bolt it to the wall frame and through the wall, placing washers between the channel and wall, and on the opposite side of the wall at wall bolts. Remove blocking from under door. Door should slide freely and should be forced close to the wall frame by the binders when closed and latched.

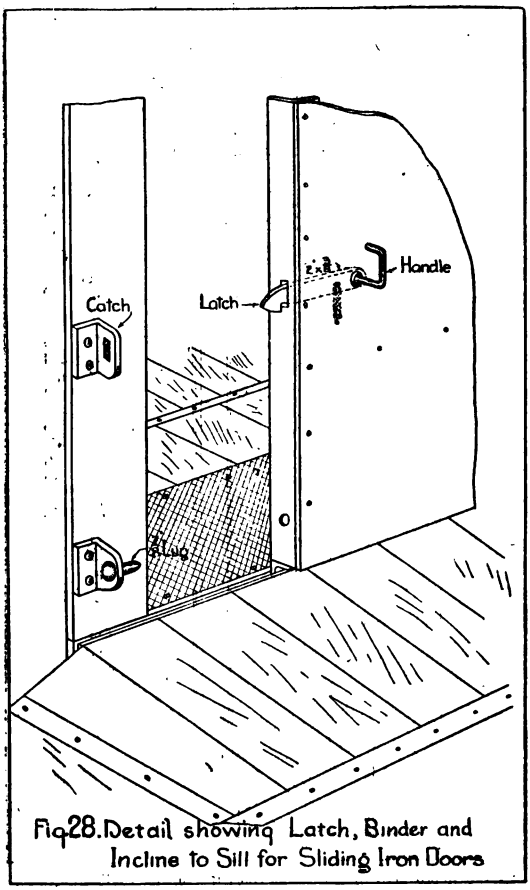

Fig. 28. Detail showing Latch, Binder and Incline to Sill for Sliding Iron Doors

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(b) When necessary a framework of slats should be built outside of sliding doors to prevent piling of stock, etc., against them.

32. AUTOMATIC SLIDING DOORS.—(a) To be so arranged that when the releasing device is operated by heat, a sufficient excess in weight will be exerted to pull and latch the door closed.

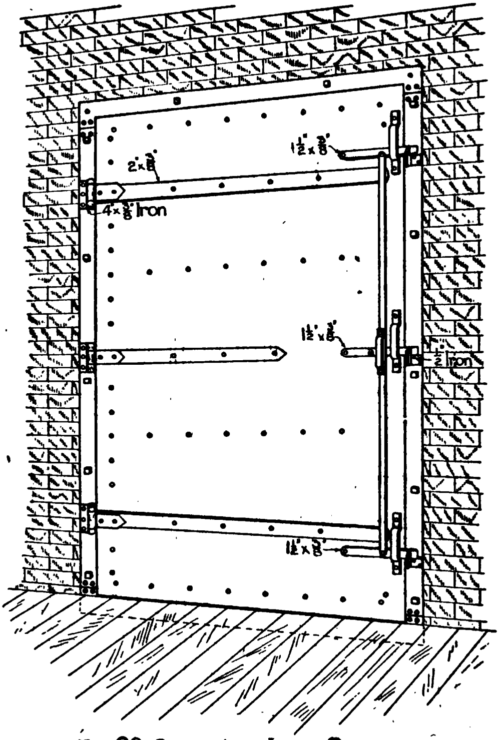

Fig. 29 Swinging Iron Door.
Showing Hinges, Latches and Catches.

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(b) Substantial phosphor bronze or galvanized steel wire cable or approved chain to be used for attaching the weights to the door. Cables or chains to pass over sheaves so designed that they cannot jump the grooves.

(c) The weights used to close the door, to be enclosed in a suitable box from floor to top of weights in extreme upward position.

(d) Door latch to be provided with a suitable coiled spring to hold it in proper position and insure fastening.

SWINGING SOLID STEEL DOORS

33. SIZE OF DOORS.—Door plates to overlap the sides and top of the wall frame at least 1 inch. Where doors are used in pairs, swinging door to overlap the standing door at least 1 inch when they come together.

34. MOUNTING SINGLE SWINGING DOORS.—After the wall frame is set, place the ~~door in~~ proper position over the opening with sufficient blocking between the bottom of the door and sill to elevate it so that the hinges and latches will engage properly. Install the hinge pins and remove the blocking. Door should turn easily and freely on the hinges. The latches should operate freely and ride up the inclines on the catches and snap into position when the door is slammed shut or closed with moderate force. See Figure 29.

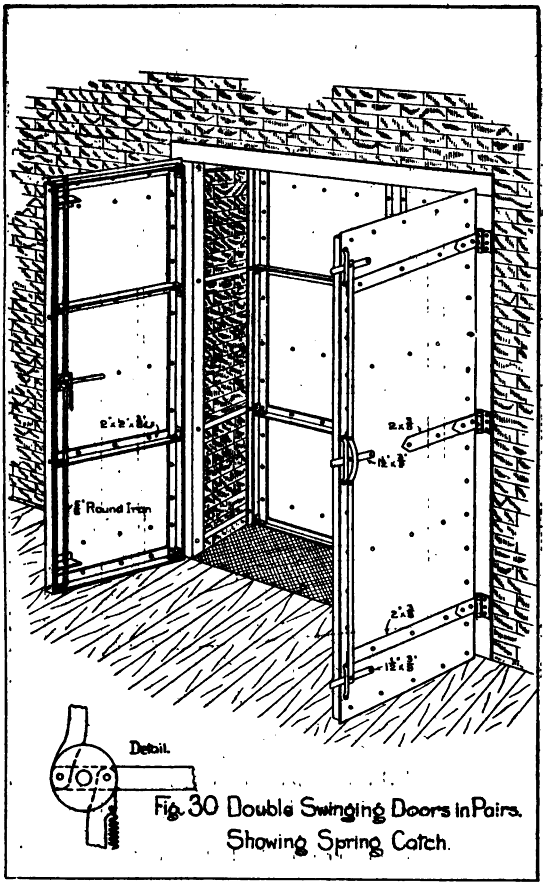

Fig. 30 Double Swinging Doors in Pairs. Showing Spring Catch.

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NOTE.—Solid steel doors are provided with at least 3 hinges and at least 3 latches working together. The doors and frames are completed and the hardware attached at the shop.

35. MOUNTING SWINGING DOORS IN PAIRS.—The rules for mounting single doors apply to doors in pairs. Standing door of the pair to be provided with spring bolts at top and bottom which enter substantial strike plates or catches at head and sill. See Figure 30.

36. AUTOMATIC SWINGING DOORS.—(a) To be so arranged that when the releasing device operates by heat, a sufficient excess in weight will be exerted to pull and latch the door closed.

(b) Substantial phosphor bronze or galvanized steel wire cable or approved chain to be used for attaching the weights to the door. Cable or chain to pass over sheaves so designed that they will not jump the grooves. Cables or chain to be sufficiently weighted to keep them taut when the doors are opened and closed.

(c) The weights used to close the door to be enclosed in a suitable box from floor to top of weights in the extreme upward position.

(d) Automatic swinging doors in pairs to be so arranged that the standing door must close and latch before the swinging door. This requires the use of an automatic stop or trigger which will hold the swinging door in the open position until the standing door has closed.

Sheet Metal Sliding Fire Doors

Standard sheet metal fire doors are fairly substantial in construction, practical under most conditions and easy to install. Doors on both sides of wall furnish a high degree of resistance to fire and to the transmission of heat for long periods of exposure. They resist fire streams well and are durable and easy to maintain.

37. SIZE AND SHAPE OF DOORS.—Doors to overlap sides and top of wall opening 4 inches. Where steel lintels are used, doors to overlap the brickwork 4 inches above upper edge of the steel, unless such lintels are fireproofed in a manner satisfactory to the Inspection Department having jurisdiction. Top of the door to conform to incline of track, ¾-inch to the foot.

38. MOUNTING SLIDING DOORS.—(a) The rules for mounting sliding tin-clad doors should be followed except as specified in the following rules.

NOTE.—Parts of the hardware for mounting sheet metal doors are especially designed, and members such as chafing strips, bumper shoes, handles and necessary reinforcements are installed before the doors leave the shop.

(b) Mounting Track.—The space between the top of the door and the track to be at least 1 inch to allow for the upward expansion of the door when heated.

NOTE.—Sheet metal doors are provided with track binders or lugs which engage the track and hold the door in position in case the hanger wheels are lifted from the track by expansion.

(c) Attaching Hangers.—Hangers to be bolted to door when in position.

NOTE.—Sheet metal doors are provided with bolt holes and any necessary reinforcements for the attachment of the hangers before they leave the shop.

(d) Attaching Binders.—Track binders to lap the track at least ½ inch. To be located 2 inches to one side of the center line of the wall bolts when the door is closed.

NOTE.—The track binders are located to one side of the track bolts so that they will clear the track brackets when the door expands upward.

Where possible, doors are to be provided with one or more rear binders in addition to the front binders and stay roll specified for tin-clad doors. Rear binders to be equally distributed between top and bottom of door and attached by through bolts as specified for front binders.

Rolling Steel Fire Doors

Standard rolling steel fire doors are substantial in construction and practicable under most conditions but are somewhat difficult to install. Doors on both sides of wall furnish a high degree of resistance to fire, and a fairly high resistance to the transmission of heat for long periods of exposure. They resist fire streams well, and are durable, fairly easy to maintain and are capable of being installed in locations where space limitations prevent the installation of other types of doors. Some types of rolling doors are difficult to operate after they have closed automatically. The type and use of these doors in any given case should be considered in its relation to the effect upon hazard to life.

39. POSITION OF DOORS.—(a) Doors subject to damage from falling materials at time of fire, to be mounted in reveal of wall so that no portion projects beyond the face of the wall.

NOTE.—The brackets and hood of rolling steel doors mounted on the face of the wall project materially from the wall and are especially subject to damage by falling material at time of fire.

(b) Doors not subject to damage from falling materials at time of fire may be mounted on the face of the wall. Inspection departments having jurisdiction to be consulted before installation.

NOTE.—Doors mounted on the face of fire walls should usually be confined to fireproof buildings where there is little if any danger of the collapse of the building and injury to the door from falling materials.

40. SIZE OF DOORS.—Doors to overlap the sides of the wall opening. Hood to fit closely against the lintels or where the door is mounted on the face of the wall; hood to be placed above the top of the opening so that bottom of the curtain will be flush with or above the top of the opening when the door is fully open.

41. MOUNTING ROLLING DOORS.—Rolling steel doors are complicated in construction and not easily installed by workmen unfamiliar with them. Where possible, their installation should be under the supervision of the manufacturer. Specifications and blue prints should be furnished covering the details of installation.

(a) Mounting Guides.—Place one of the guides in proper position at side of wall opening (on highest side if sill is not perfectly level) and see that it is plumb and that proper clearance is allowed for expansion between bottom of guide and sill. Mark slots on wall at holes for wall bolts. Remove guide and mark long crosses at end of slots furthest from fixed end of guide and carefully drill holes through wall. Place opposite guide in position on wall and bolt both guides together with ½-inch through bolts, care being taken to see that guides are plumb and in proper position after bolting.

Mark a level line horizontally from top of guides to opposite side of wall opening, and install guides on this side as described above. Use gauge stick to maintain proper horizontal distance between the bottom of grooves in guides.

NOTE.—Each guide is provided with slotted holes spaced not more than 18 inches, and plates with slip joints to allow for expansion of the guides when heated. Sufficient clearness is provided between the sides of the curtains and the bottom of the grooves in the guides to allow for the expansion of the curtain when heated.

(b) Mounting Brackets.—Place brackets in proper position at top of guides and mark holes on lintel or wall. Remove brackets and drill holes for bolts. Bolt brackets in position, care being taken to see that they are plumb and true, that they are the proper distance apart, that the bearings are level with each other, and that the mouth of the brackets register perfectly with the grooves.

NOTE.—Clearance is provided between the ends of the barrel and the brackets to allow for expansion when the barrel is heated. The mouth of the bracket must register with the grooves in order to prevent interference with the movement of the curtain.

(c) Mounting Barrel.—Place barrel in position in bearings so that it is perfectly level and will turn without binding. Install attachments to barrel.

(d) Mounting Curtain.—Remove one guide and bolt top section of curtain to barrel or rings. Slip the lower sections of curtain together and fasten by end locks when in position. Replace guide and balance curtain by adjustment of spring.

NOTE.—The curtains of some doors are installed without being separated into sections.

(e) Mounting Hoods.—Place hoods in position and bolt to brackets and lintel. When mounted on face of wall, attach wall piece of hood securely to the wall by bolts or nailing into mortar joints. Bolt housing on outside of brackets in position.

(f) Test.—Test operation of the doors after installation and alter adjustments if necessary to make them operate freely.

Hollow Metal Swinging Fire Doors

Standard Class A hollow metal fire doors are provided with insulated stiles and rails at least 1¾ inches in thickness, and insulated panels at least 1 inch in thickness. In moderate sizes they are substantial in construction, practical under most conditions, fairly easy to install and permit the use of concealed hardware. Mounted on both sides of the wall, they furnish a high degree of resistance to fire and to the transmission of heat for long periods of exposure. They resist fire streams well, are durable and are easy to operate, and fairly easy to maintain.

42. SIZE OF DOORS.—(a) Single swinging doors not to exceed 4 feet in width or 8 feet in height, to shut into rabbets formed by the stops on the wall frame and fit the opening closely.

(b) Swinging doors in pairs not to exceed 6 feet in width or 8 feet in height, to shut into rabbets formed by the stops on the wall frame, to fit the opening closely, and to be provided with rabbeted edges or an astragal where they come together at the middle.

43. MOUNTING SINGLE SWINGING DOORS.—(a) To be mounted in approved wall frames properly installed in the wall.

(b) Doors not exceeding 3½ feet in width or 5 feet in height to be provided with at least two approved hinges. Doors in excess of 5 feet and not more than 7½ feet in height to be provided with at least 3 approved hinges. Doors in excess of 7½ feet and not more than 8 feet in height to be provided with at least 4 approved hinges.

(c) To be equipped with an approved three-point locking mechanism. The latch bolts to engage catches in the jamb of the wall frame at least ⅝ inch.

44. MOUNTING SWINGING DOORS IN PAIRS.—(a) Doors to be mounted in an approved wall frame properly installed in the wall.

(b) Each door to be provided with approved hinges as specified for single doors. See Rule 43b.

(c) The active door of the pair to be provided with an approved three-point locking mechanism as specified for single doors. The latch bolts to engage catches in the stile of the opposite door at least ⅝ inch.

(d) The standing or normally stationary door to be provided with an approved two-point locking mechanism engaging catches in the head and sill at least ⅝ inch.

(e) Doors to be provided with an approved interference device to prevent the wrong door from closing first.

45. OPERATION OF DOORS.—Doors to be mounted in such a manner that they will swing easily and freely on their hinges and close accurately against the stops on the wall frame, fitting the opening snugly but without binding. The latch bolts should operate easily and register properly with the catches, securely fastening the door when closed easily or with considerable force.

NOTE.—Doors installed in new buildings may require several readjustments of the locking mechanism to insure proper operation of locks and engagement of the latches, as slight settlements in new buildings are practically unavoidable and sometimes disarrange the proper registration of the latch bolts.

Constant operation of the door causes the hinges to wear, and this wear may in time be sufficient to cause the door to bind in the frame. Hinges should therefore be examined at fairly frequent intervals, and repaired or replaced if necessary.

REGULATIONS FOR THE PROTECTION (CLASS B) OF OPENINGS IN ENCLOSURES TO VERTICAL COMMUNICATIONS THROUGH BUILDINGS

Enclosures to vertical openings through buildings are of the greatest importance in safeguarding life, are next in importance to fire walls in preventing the spread of fire, and require the use of doors that can be reliably operated at exits, and of fire retardants of a high order at all wall openings. While these enclosures are subject to fire exposures of the same severity as fire walls, the conditions in these situations in buildings are such that a single fire retardant can be safely employed in standard shafts. This is made possible by the fact that the failure of two fire retardants, always located a considerable distance apart, must occur before fire can pass from one fire section to another or from story to story. Only such fire retardants are included in this class as have been shown by experience and tests to furnish a high degree of fire protection when installed on one side of the wall, and, if used as exit doors, to offer no serious accident hazard under normal or emergency conditions in this situation.

Fire retardants fulfilling the requirements for division can be employed for openings into vertical shafts where the type and pattern are suitable.

General Regulations

46. NUMBER AND SIZE OF WALL OPENINGS. See Rules 1 and 1, page 367.

48. NUMBER OF DOORS.—(a) Each opening in standard shafts communicating with more than one building or section of a building to be provided with an approved fire door. Doors to be of the normally closed or automatic type.

NOTE.—Normally closed doors are preferable where the nature of the business is such that they are not likely to be blocked open.

(b) Each opening in sub-standard shafts communicating with more than one building or section of a building to be provided with an approved fire door, and in addition, each opening into the shaft through the fire wall to be provided with an approved door for division walls. Doors to be of the normally closed or automatic type.

49. MASONRY AT WALL OPENINGS. See Rule 4, page 367.

50. SILLS.—(a) Any of the flush sills specified in Rule 5 may be used in shaft openings.

(b) To be substantial metal threshold plates with anti-slip surface, extending into the masonry at each side of the opening and anchored to the masonry beneath them.

NOTE.—Where the threshold plates specified above are used in connection with metal frames, they may be attached to such frames in lieu of projection into the masonry at the sides of the opening.

(c) In buildings with non-combustible floors no special sill construction is necessary, if the floor structure is extended through the opening.

51. LINTELS.—Any of the lintels specified in Rule 6, page 373, may be used in shaft openings.

52. WALL FRAMES.—(a) Any of the frames specified in Rule 7, page 373, may be used in shaft openings.

(b) Frames to be made of substantial structural steel channels at the sides and top of the opening. Channels to be securely fastened together at the upper corners and to the sill, or threshold plate where used. In case no sill is used, channels at sides of opening to extend into floor structure at least 3 inches. Jambs to be securely anchored to masonry at sides of opening, at intervals not exceeding 24 inches. Where swinging doors are used, head and jambs to be provided with metal door stops projecting at least ½ inch and securely fastened to the frame members. These stops may be formed in special sheet metal channels overlapping the structural steel channels.

Where channel iron frames do not overlap both sides of the wall, anchors to extend back in such a manner as to engage the masonry at the middle of the wall.

(c) Frames for swinging doors may be made of channel shaped sections of sheet metal at least No. 18 U. S. gauge in thickness. Channels to be at least 5 inches wide, securely fastened together at the upper corners and to the sill or threshold plate if one is used. In case no sill is used, channels at sides of opening to extend into floor structure at least 3 inches. Jambs to be secured to masonry at sides of opening at intervals not more than 24 inches. Where flanges of channels do not lap both sides of the wall, anchors to extend back in such a manner as to engage the masonry at the center of the wall.

Head and jambs to be provided with metal door stops projecting at least ½ inch; securely fastened to the frame members. These stops may be formed in special sheet metal channels overlapping the channel in contact with the masonry.

53. MEASUREMENT FOR SIZE OF FIRE DOORS. See Rule 8, page 376.

Openings in walls to be carefully measured before doors are built and maximum dimensions used in determining overlap of doors. Where wall frames are employed the size of the door is determined by the opening in the frame.

54. TYPE OF DOOR, DIRECTION OF OPERATION.—(a) Doors at openings to stairways to be of the swinging type where practicable. To open in the direction of exit travel in such manner as not to obstruct the passage or the operation of other doors.

NOTE.—Properly installed swinging doors are easier to operate, especially under emergency conditions, than any other type and offer less resistance to rapid and emergency egress.

(b) Horizontally sliding doors may be used at openings to stairways where conditions prevent the use of swinging doors. To open in such manner as not to obstruct the passage or the operation of other doors.

NOTE.—Sliding doors are more difficult to operate than swinging doors, especially at times of emergency, but are less objectionable at exits than vertical sliding or rolling doors.

(c) Vertical doors and rolling doors not to be used at openings to stairways.

NOTE.—Doors of this type are usually difficult to operate, and the method of operating them is not obvious or as well understood as the methods of operating swinging or horizontally sliding doors. They may be safely employed at openings in enclosures to vertical shafts that are not used as emergency exits.

55. AUTOMATIC DOORS.—Doors at openings to enclosures to vertical communications through buildings to be of the normally closed or automatic types. Doors not to be provided with attachments that will prevent the operation of the closing devices.

NOTE.—Normally closed doors are doors arranged to close by gravity, or doors equipped with an approved door check or device to insure proper closing after the door has been opened. Automatic doors are doors equipped to close by the action of heat if left open.

56. CARE AND MAINTENANCE.—(a) Doors should be ready for instant use at all times. Therefore, it is necessary to keep surroundings clear of everything that would be likely to obstruct or interfere with their free operation. They should be kept closed and fastened as much of the time as possible.

(b) Where subject to deterioration from corrosion, doors should be painted at fairly frequent intervals.

(c) Hardware should be examined at frequent intervals, and any parts rendered inoperative should be promptly replaced.

(d) Hinges are especially subject to wear and for this reason should be inspected frequently and kept in repair.

(e) Guides and bearings to be kept well greased to facilitate operation.

(f) Doors of the sliding pattern should be stenciled on the room side with the words, "To Open," and an arrow indicating the direction. Swinging doors should be stenciled, "Turn Knob and Push," or "Press Down Lever and Push," as the case may be.

Swinging Hollow Metal Fire Doors

Standard Class B hollow metal fire doors are provided with insulated stiles and rails at least 1½ inches in thickness, and insulated panels at least ¼ inch in thickness. In moderate sizes they are substantial in construction, practical under most conditions, fairly easy to install, and permit the use of concealed hardware. Mounted on one side of vertical shaft walls, they furnish a high degree of resistance to fire and a fairly high degree of resistance to the transmission of heat for long periods of exposure. They resist fire streams well, are durable and easy to operate, and fairly easy to maintain.

See Rules 42 to 45 inclusive, pages 397 and 398.

Tin-Clad Fire Doors

Standard Class B tin-clad fire doors are the same as Class A tin-clad doors, except that the cores are made of two plies. In moderate sizes they are fairly substantial in construction, practical under most conditions, and easy to install. Mounted on one side of the wall, they furnish a high degree of resistance to fire and to the transmission of heat for fairly long periods of exposure, and resist fire streams fairly well. Under adverse conditions of service they are liable to deteriorate rapidly, and are difficult to maintain.

The rules covering vent holes, size and shape of doors, and mounting sliding and swinging Class A tin-clad fire doors to apply to two-ply tin-clad fire doors for Class B situations. Se Rules 19 to 27 inclusive, pages 378 to 388, and list of Approved Hardware for these doors.

Rolling Steel Elevator Doors

Standard rolling steel doors are substantial in construction, practical under most conditions, but are somewhat difficult to install. Mounted on one side of vertical shaft walls they furnish a high degree of resistance to fire for long periods of exposure, and a sufficient resistance to the transmission of heat in these situations. They resist fire streams well, are durable, fairly easy to maintain, and capable of being installed in locations where space limitations prevent the installation of other types of doors.

Some types of rolling steel elevator doors are difficult to operate after they have closed automatically. The type and use of these doors in any given case should be considered in its relation to effect upon hazard to life.

Position of Doors.—(a) Doors in enclosing walls of elevator shafts which communicate with more than one fire section, and which are subject to damage from falling materials at time of fire, to be mounted in reveal of wall so that no portion projects beyond the face of the wall.

(b) Doors in enclosing walls of elevator shafts which do not communicate with more than one fire section, and doors which are not subject to damage from falling material at time of fire, may be mounted on the face of the wall. Inspection departments having jurisdiction to be consulted before installation.

Note.—Doors mounted on the face of the wall should usually be confined to elevator shafts in fireproof buildings, and to elevator shafts serving a single fire section only.

Size of Doors.—Doors not to exceed sizes suitable for openings 8 feet in width and 9 feet in height. To overlap the sides of the wall opening. Hood to fit closely against the lintel, or where the door is mounted on the face of the wall, hood to be placed above the top of the opening so that the bottom of the curtain will be flush with or above the top of the opening when the door is fully open.

Mounting Rolling Doors.—The rules for mounting rolling steel doors at openings in fire walls to be followed, except that doors are installed only on one side of wall. See Rule 41 a to f inclusive, page 396.

Counterbalanced Elevator Doors

Standard counterbalanced elevator doors are substantial in construction, practical in many elevator enclosures, but are somewhat difficult to install. Mounted on one side of shaft walls they furnish a high degree of resistance to fire for long periods of exposure and a sufficient resistance to the transmission of heat in these situations. They resist fire streams well, are durable and generally easy to maintain.

Size of Doors.—(a) Doors not to exceed sizes suitable for openings 8 feet in width and 10 feet in height. To lap the opening at least 2 inches on the sides, and at least 3 inches at top and bottom.

(b) Door sections to engage the guides on each side at least 1 inch with ½-inch clearance in each guide for lateral expansion.

MOUNTING COUNTERBALANCED ELEVATOR DOORS.—Counterbalanced elevator doors are not easily installed by workmen unfamiliar with them. Where possible, their installation should be under the supervision of the manufacturer. Specifications and blue prints should be furnished covering the details of installation. The elevator should be available during the installation of doors.

(a) Mounting Wall Guides.—Place the guides in proper position at sides of opening and see that they are perfectly plumb, the proper distance apart, and that the attachments on each guide are directly opposite each other on a level line. Mark slots on wall at holes for wall bolts, remove guides and mark long crosses at ends of slots furthest away from the fixed point on the guides and drill holes through wall exactly where marked. Replace guides and bolt to wall with ½-inch through bolts, placing washers on opposite side of wall.

NOTE.—The guides are assembled at the shop in unit lengths approximately equal to story heights, 2 inches being allowed between units for clearance and expansion. The guides are provided with one round hole and slots spaced not more than 18 inches at the door opening and not more than 42 inches above the door opening. The wall bolt at the round hole is the fixed point on the guides.

Where the doors are mounted on non-standard enclosing walls, the ends of the wall guides to be securely anchored to the floor structure at floor levels.

NOTE.—If securely attached to the floors, the wall guides serve as structural supports to both door and wall.

Wall guides may be attached to standard wall frames by slotted clips and bolts. See Rules 7 and 52b, pages 373 and 399.

NOTE.—The wall frames are liable to bulge when exposed to fire and affect the fire retardant properties of doors attached to them, unless slotted connections are employed.

(b) Mounting Door Sections.—Place door sections in position in guides so that latches and stops engage properly, attach chains to counterbalancing mechanism, and adjust so that the door closes and latches properly when operated.

Metal-Clad Doors

Standard Class B metal-clad fire doors are provided with framed wooden cores, covered with sheet metal, with stiles and rails at least 1½ inches in thickness and with depressed panels. In moderate sizes they are fairly substantial in construction, practical under most conditions, fairly easy to install, but do not permit of concealed hardware. Mounted on one side of vertical shaft walls they furnish a high degree of resistance to fire and to the transmission of heat for fairly long periods of exposure, and resist fire streams fairly well. Under adverse conditions of service they are liable to deteriorate rapidly and are difficult to maintain.

SWINGING METAL-CLAD DOORS

SIZE OF DOORS.—(a) Single swinging doors not to exceed 4 feet in width or 8 feet in height, to shut into rabbets formed by the stops on the wall frame and fit the opening closely.

(b) Swinging doors in pairs not to exceed 6 feet in width or 8 feet in height, to shut into rabbets formed by the stops on the wall frame, to fit the opening closely, and to be provided with rabbeted edges or an astragal where they come together at the middle.

MOUNTING SINGLE SWINGING DOORS.—(a) To be mounted in approved wall frames properly installed in the wall.

(b) Doors not exceeding 3½ feet in width or 5 feet in height to be provided with at least two approved hinges. Doors in excess of 5 feet, and not more than 7½ feet in height to be provided with at least 3 approved hinges. Doors in excess of 7½ feet and not more than 8 feet in height to be provided with at least 4 approved hinges.

(c) Doors to be equipped with an approved three-latch mechanism, installed as nearly as possible in the manner specified for swinging tin-clad fire doors. See Rule 24c, page 386.

MOUNTING SWINGING DOORS IN PAIRS.—(a) To be mounted in approved wall frames properly installed in the wall.

(b) Each door to be provided with approved hinges as specified for single doors.

(c) The active door of the pair to be equipped with an approved three-latch mechanism, installed as nearly as possible in the manner specified for swinging tin-clad fire doors. See Rule 24c, page 386.

(d) The standing or normally stationary door to be equipped with an approved door bolt at top and bottom and with catches for the latches on the active door, installed as nearly as possible in the manner specified for tin-clad doors. See Rules 25a, b, page 388.

(e) Doors to be provided with an approved interference device to prevent the wrong door from closing first.

OPERATION OF DOORS.—Doors to be mounted in such a manner that they will swing easily and freely on their hinges, and close accurately against the stops on the wall frame without binding. The latches should operate freely on their pivots and ride up the inclines on the catches and snap into position when the door is slammed shut or closed with moderate force.

REGULATIONS FOR THE PROTECTION (CLASS C) OF OPENINGS IN CORRIDOR AND ROOM PARTITIONS

Partitions used for the subdivision of fire sections of buildings are of very considerable value in safeguarding life and preventing the rapid spread of fire through buildings. While of lesser importance from the fire protection viewpoint than fire walls and enclosures to vertical communications through buildings, all openings in interior partitions should be provided with effective barriers to the passage of fire. This can be accomplished by the use of fire retardants that fulfill all service requirements but do not possess the qualifications for the protection of openings in fire walls, openings in enclosing walls to rooms containing specially hazardous processes, and vertical shafts. Only such fire retardants are included in this class as have been shown by experience and tests to prevent the spread of fire for fairly long periods when installed on one side of corridor and room partitions, and to offer no serious accident hazard under normal or emergency conditions in this situation.

Fire retardants fulfilling Class A and Class B requirements can be employed for openings in corridor and room partitions where the type and pattern are suitable.

General Regulations

NUMBER AND SIZE OF OPENINGS.—Openings to be in sufficient number and of ample size to provide for rapid egress toward the exits, otherwise to be as few and as small as the circumstances will permit.

THRESHOLDS.—To be made of non-combustible material with upper surface treated to prevent slipping.

LINTELS.—Lintels to be of non-combustible material capable of safely sustaining the superimposed loads, or partitions to be so constructed that the frame will not be subjected to material stress.

WALL FRAMES.—(a) To consist of structural or sheet steel channels of sufficient width to lap the sides of the partition.

(b) To be securely anchored to partition, and where they extend from floor to ceiling, to be securely anchored at top and bottom.

FINISH AT OPENINGS.—The casing and trim at openings to be preferably of non-combustible material.

Hollow Metal and Metal-Clad Doors

Standard Class C doors of these patterns may be provided with wired glass upper panels, and limited amounts of heat insulating materials. In moderate sizes they are fairly substantial in construction, practical under most conditions, and fairly easy to install. Mounted in corridor and room partitions they furnish a fairly high degree of resistance to fire for limited periods and sufficient resistance to the transmission of heat in this situation. When equipped with wired glass panels they afford only a limited resistance to fire streams. Under adverse conditions of service the metal-clad doors are liable to deteriorate rapidly and are difficult to maintain.

SIZE OF DOORS.—(a) Single swinging doors not to exceed 4 feet in width or 9 feet in height, to shut into rabbets formed by the stops on the wall frame and fit the opening closely.

(b) Swinging doors in pairs not to exceed 8 feet in width or 9 feet in height, to shut into rabbets formed by the stops on the wall frame, to fit the opening closely, and also to fit together closely where they come together at the middle.

MOUNTING SWINGING DOORS.—(a) To be mounted in approved wall frames properly installed in the wall or partition.

(b) Doors not exceeding 3½ feet in width or 5 feet in height to be provided with at least 2 approved hinges. Doors in excess of 5 feet and not more than 7½ feet in height to be provided with at least 3 approved hinges. Doors in excess of 7½ feet and not more than 9 feet in height to be provided with at least 4 approved hinges.

(c) Doors to be equipped with the ordinary heavy hardware.

(d) Doors to be mounted in such a manner that they will swing easily and freely on their hinges and open and close without binding.

REGULATIONS FOR THE PROTECTION (CLASS D) OF OPENINGS IN EXTERIOR WALLS SUBJECT TO SEVERE FIRE EXPOSURE

The importance of exterior walls as a safeguard to life at time of fire, and in preventing fire from entering and spreading through buildings, makes it essential that all openings in such walls subject to severe exposing fires be protected by efficient methods. Only such fire retardants are included in this class as have been shown by experience and tests to furnish a high degree of fire protection when installed on one side of the wall, and, if used at exit openings, to offer no serious accident hazard under normal or emergency conditions in this situation.

Fire retardants fulfilling Class A or Class B requirements can be employed for the protection of openings in exterior walls subject to severe fire exposure where the type and pattern are suitable.

General Regulations

NUMBER AND SIZE OF WALL OPENINGS.—Openings to be in sufficient number and of ample size to provide for rapid egress from the building, and to furnish sufficient light and ventilation, otherwise to be as few and small as the circumstances will permit.

MASONRY AT WALL OPENINGS.—Walls to be plumb and true and present smooth masonry surfaces without combustible trim at openings.

SILLS.—(a) To be of non-combustible material suitable for the service intended, and provided with any grooves, holes or recesses necessary for the proper installation of the fire retardants used to protect the openings.

(b) To be firmly embedded in mortar, and securely bonded or anchored to the masonry.

LINTELS.—To be of non-combustible material and designed for the proper installation of the fire retardants used to protect the openings.

NOTE.—The lintels specified for openings in fire walls may be used for openings in exterior walls, particularly for door openings. See Rule 6, page 373.

WALL FRAMES.—Wall frames for exterior door openings to conform in all essential particulars with the requirements for openings in fire walls or vertical communications through buildings. See Rules 7, page 373, and 52, page 399.

MEASUREMENT FOR SIZE OF FIRE RETARDANTS.—Openings in exterior walls to be carefully measured before the doors or shutters are built. Where wall frames are employed, the size is to be determined by the opening in the frame.

NOTE.—Openings in exterior walls are very apt to vary from the sizes given on plans. The size and shape of the opening in wall frames is frequently altered by distortion incidental to shipment and installation. It is important therefore that the openings be carefully measured before the doors or shutters are built.

TYPE OF DOORS—DIRECTION OF OPERATION.—Doors at openings used as exits to be of the swinging type where practicable. To open in the direction of exit travel in such a manner as not to obstruct the passage or the operation of other doors.

CARE AND MAINTENANCE.—(a) Exterior fire doors and shutters should be ready for instant use at all times, therefore it is necessary to keep the surroundings clear of everything that would be likely to obstruct or interfere with their free operation. They should be kept closed and fastened nights, Sundays and holidays, and whenever the openings are not in use.

(b) Never tack any tin on tin-clad doors or shutters. When tin becomes worn, substitute new sheets in the same manner as when applying the original covering.

PAINTING.—Exterior doors and shutters to be given one good coat of paint before they leave the shop, and at least one coat after they are installed. Rolling steel doors and shutters not to be opened (coiled up) until the paint has dried sufficiently to prevent adhesion between the parts. Exterior doors and shutters to be repainted at fairly frequent intervals to prevent deterioration. Paint to be satisfactory to inspection departments having jurisdiction.

Tin-Clad Fire Shutters

87. SIZE AND SHAPE OF SHUTTERS.—Shutters to overlap sides and top of window opening 4 inches, or close into the opening. Shutters in pairs to fit closely where they come together at the middle.

NOTE.—Shutters in pairs do not furnish as reliable protection as single shutters. Joints between shutters may be protected by ¼ x 2¾ inch steel astragal bolted to one shutter by carriage bolts spaced 10 inches. The window openings should be carefully measured before the shutters are built.

88. MOUNTING SHUTTERS.—(a) Attachment of Pin or Eye Blocks.—To be securely set in wall or bolted through wall.

(b) Attachment of Hinges.—Shutters in excess of 7 feet in height or 6 feet in width to be provided with three hinges. Hinges to be secured by bolts passing through the shutter, placing washers under bolt heads. The rules for attaching hinges to tin-clad fire doors should be followed as far as possible. See Rule 24 b, page 386.

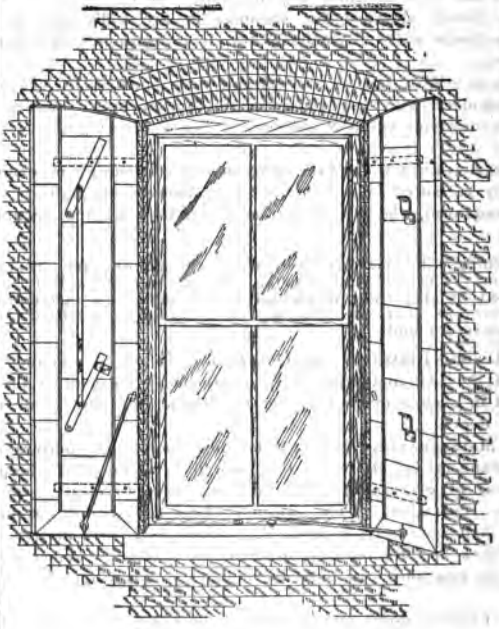

Fig. 31. Tin Clad Fire Shutters.

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(c) Attaching Latches.—Shutters to be secured shut by at least two steel bars or latches working together and spaced about one third the distance from top and bottom of the window opening. Latches to pivot on ⅝-inch bolts through the shutters. See Figure 31.

(d) Attaching Catches.—To be securely set in wall. Catches for shutters in pairs to be provided with a flare and attached to the shutter by two ⅝-inch through bolts. Hooks or gravity catches securely attached to wall to be provided to hold the shutter in position when open. See Figure 31.

(e) Operation.—At least one shutter in three on each story above the first and below the seventh, and shutters next to fire escapes and above adjoining buildings to be constructed so that they can be operated from both inside and outside.

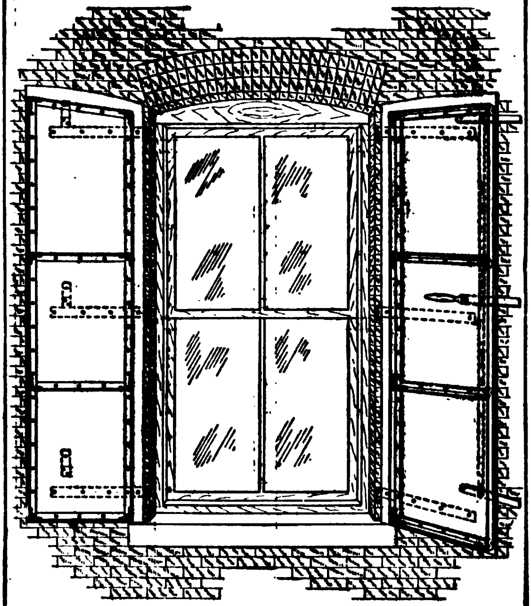

Fig. 32. Iron Shutters, Open.

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89. Sliding Shutters.—Sliding shutters not to be used if avoidable. If used on the outside, metal shields should be provided to prevent accumulation of snow and ice on track.

Solid Steel and Sheet Metal Shutters

90. SIZE AND SHAPE OF SHUTTERS.—Shutters to overlap sides and top of window opening at least 1½ inches or close into the opening. Bottom of shutter to fit the sill closely where it is not practical to lap it. Shutters in pairs to lap each other at least 1½ inches when they come together at the middle. See Figures 32 and 33.

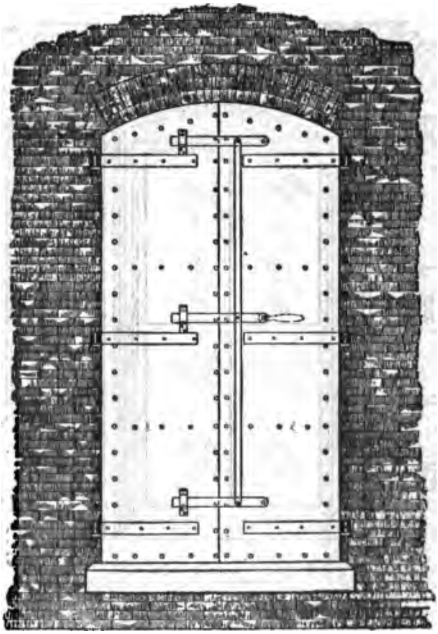

Fig. 33. Iron Shutters, Closed.

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NOTE.—The window openings should be carefully measured before the shutters are built.

91. MOUNTING SHUTTERS.—(a) Attachments of Pin or Eye Blocks.—To be securely set in wall or bolted through wall.

(b) Attachment of Hinges.—Hinges not to exceed 24 inches apart when shutter is in excess of 6 feet in height. Set the shutters in positions with ends of hinges in position on pin or eye blocks. Shutters should turn easily and freely on the hinges. See Figures 32 and 33.

NOTE.—The hinges are attached to solid steel and sheet metal shutters at the top.

(c) Attaching Latches.—Shutters to be provided with at least two latches, and where more than 6 feet in height latches not to exceed 24 inches apart.

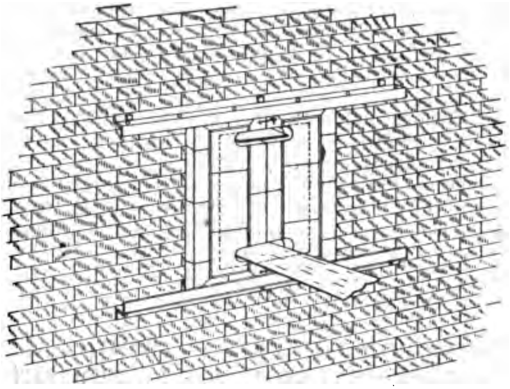

Fig 34 Door to cover Belt Hole Opening.
Dotted lines show opening through wall

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Latches to work together and to be installed before the shutter is mounted. Latches to extend at least one third the distance across the opposite shutter when shutters in pairs are used. See Figures 32 and 33.

(d) Attaching Catches.—To be securely set in wall, or where shutters are in pairs, to be securely riveted to the standing shutter of the pair. Hooks or gravity catches securely attached to wall to be provided to hold the shutter in position when open. See Figures 32 and 33.

(e) Operation.—At least one shutter in three on each story above the first and below the seventh, and shutters next to fire escapes and above adjoining buildings, to be constructed so that they can be operated from both inside and outside.

Rolling Steel Fire Shutters

92. POSITION OF SHUTTERS.—Shutters to be mounted on the face of wall or coil may be mounted in the wall when the shutter is so designed that the curtain is located outside of the window frame when the shutter is closed.

93. SIZE OF SHUTTERS.—Shutters not to exceed sizes suitable for window openings 10 feet wide by 10 feet in height, and to overlap openings at the sides and top. Hood to be placed above the top of the opening, or in the wall over the opening so that the bottom of the curtain will be flush with or above the top of the opening when the shutter is fully open.

94. MOUNTING ROLLING SHUTTERS.—Rolling steel shutters are complicated in construction and not easily installed by workmen unfamiliar with them. Where possible, their installation should be under the supervision of the manufacturer. Specifications and blue prints should be furnished covering the details of installation.

The rules for mounting rolling steel fire doors to be followed in mounting rolling shutters, except that doors are installed only on one side of wall. See Rules 41a to 43, inclusive, pages 396 and 397.

95. TESTING ROLLING SHUTTERS.—Shutters to be tested after installation, and adjustments altered, if necessary, to make them operate freely.

NOTE.—Rolling shutters should be provided with approved attachments for conveniently testing their operation from the inside of the building, and with approved safety attachments to prevent their operation, while windows are being washed. These attachments to be so designed that the shutters cannot be left in an inoperative condition.

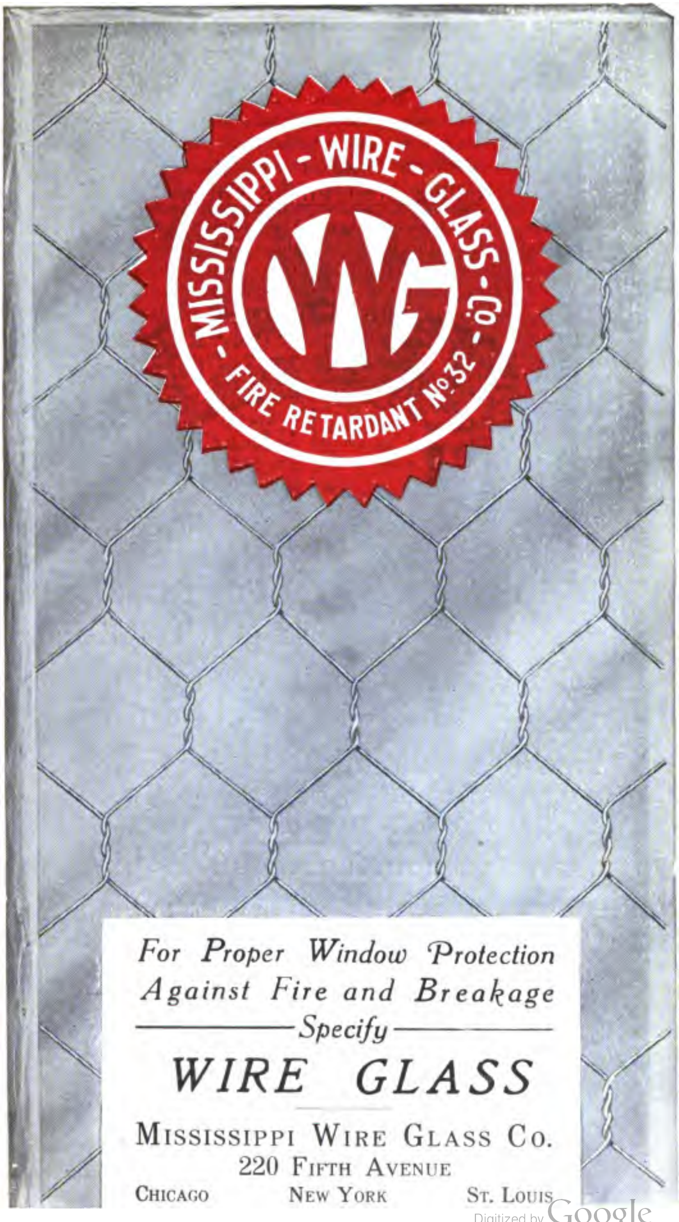
REGULATIONS FOR THE PROTECTION (CLASS E) OF OPENINGS IN EXTERIOR WALLS SUBJECT TO MODERATE FIRE EXPOSURE

Openings in exterior walls, not subject to severe fire exposure, may be efficiently protected by devices which will not safely withstand the high temperatures of severe fire exposures on the exterior of buildings, or the temperatures of fires on the interior of buildings. Only such fire retardants are included in this class as have been shown by experience and tests to furnish a high degree of fire protection when installed on one side of exterior walls not subject to severe fire exposure, and, if used at exit openings, to offer no serious accident hazard under normal or emergency conditions in this situation.

Fire retardants fulfilling Class A, B or D requirements can be employed for the protection of openings in exterior walls not subject to severe fire exposure, where the type and pattern are suitable.

General Regulations

96. NUMBER AND SIZE OF WALL OPENINGS.—Openings to be sufficient in number and of ample size to provide for rapid egress from the building, and to furnish sufficient light and ventilation, otherwise to be as few and as small as the circumstances will permit.



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97. MASONRY AT WALL OPENINGS.—Walls to be plumb and true, and to present smooth masonry surfaces at edges without combustible trim at openings.

98. SILLS AND LINTELS.—To be of non-combustible material suitable for the service intended, designed for the proper installation of the retardants used to protect the openings, and firmly embedded in mortar and securely bonded or anchored in position.

NOTE.—The sills and lintels specified for openings in fire walls may be used for openings in exterior walls when suitable. See Rules 5 and 6, page 373.

99. WALL FRAMES FOR DOORS.—Door frames specified for openings in Class A and B situations may be used for door openings in exterior walls. See Rules 7 and 52, pages 373 and 399.

100. MULLIONS.—(a) Bearing mullions to be of masonry or of structural members protected by at least 2 inches of fireproofing material on all sides.

(b) Non-bearing mullions and horizontal structural dividing members to consist of steel I-beams not smaller than 5 inches, securely fastened to the wall and protected by at least 2 inches of fireproofing material on the flanges and at least 2½ inches next on the web.

101. CARE AND MAINTENANCE.—Fire retardants at exterior openings to be kept well painted to prevent deterioration, to be kept clean of everything that would be likely to obstruct or interfere with their free operation, and to be frequently tested and maintained in perfect working order.

Fire Windows

Wired glass windows are fairly substantial in construction, practical under most conditions, easy to install and to maintain, furnish a fairly high degree of resistance to fire, but their use is restricted by inherent limitations of the glass which transmits heat readily, and melts at comparatively low temperatures. For situations where the exposure is not severe they will prevent the spread of fire from one building to another or from one story to another in the same building.

102. SIZE OF FIRE WINDOWS.—Metal frame containing the sash or glass not to exceed 5 feet by 9 feet between supports. Larger openings to be reinforced at every point of division by mullions or horizontal structural members constructed as specified in Rule 100a and b.

103. SIZE OF GLASS FOR FIRE WINDOWS.—Area of wired glass between supports not to exceed 720 square inches, and the longer dimension of the glass not to exceed 48 inches.

104. INSTALLATION OF FIRE WINDOWS.—(a) Sills of hollow metal window frames to be filled with non-combustible material capable of preventing distortion.

(b) Frames to be set upon a bed of mortar and supported by shims or wedges to be removed after masonry is completed. Vertical members to be plumb and true, and horizontal members level. Frames to be securely braced in position until held by the masonry or other attachments.

(c) Frames installed before the sashes are in position to be securely cross braced to prevent distortion while the wall is being built.

(d) Masonry to be set close to walling in flanges, weight pockets or extending portions of the window frame, and wall anchors to be properly set into the masonry as the work progresses. Joints between the frame and wall to be carefully pointed up on both sides of the window.

(e) Arches or lintels to be set with reference to extending frame members and at least ¼-inch clearance allowed so as not to subject the frame to loads by settlements. Joints between frame and arch or lintel to be filled with mortar and made tight by pointing.

NOTE.—New masonry is liable to settle slightly and distort the frame if proper allowances are not made in setting.

(f) Frames set in old openings to be firmly secured to the wall structure, first wetting old masonry to prevent the rapid absorption of moisture in mortar. All joints between frame and wall to be filled with mortar and made tight by pointing.

(g) Window frames to be thoroughly protected by boxing if window opening is used for the introduction of building materials.

(h) Directions for installation to be furnished for windows, covering which published installation rules do not apply.

REGULATIONS FOR THE CONSTRUCTION OF FIRE WINDOWS *

Hollow metallic windows may be divided into six general types, namely: Sliding Windows, Pivoted Windows, Casement Windows, Top Hinged Windows, Stationary Windows, and Tilting Windows.

SLIDING WINDOWS.—Sliding windows are windows having two sashes ordinarily designed to slide up and down. The motions of these sashes may be independent of each other and controlled by weights, in which case the window is called a double hung window, or one sash may counterbalance the other, in which case the window is called a counterbalanced window.

While it is possible to design windows which will slide horizontally, such windows are seldom made and the term "sliding window" is, therefore, generally considered as applying exclusively to the vertical sliding type.

PIVOTED WINDOWS.—A pivoted window is a window having one or more of the sashes mounted on pivots allowing each movable sash to be turned on an axis.

CASEMENT WINDOWS.—A casement window is a window having the sashes attached to the frame by hinges at a vertical edge and operating in the same manner as a door.

TOP HINGED WINDOWS.—A top hinged window is a window having the sash attached to the frame by hinges at the upper horizontal edge.

STATIONARY WINDOWS.—A stationary window is a window having the sash fixed in one position.

TILTING WINDOWS.—A tilting window is a window in which the sashes are attached to the frame, and to each other in such a manner that a sliding and tilting movement of the sashes is secured.

TWIN WINDOWS.—A twin window is a window the sashes of which are mounted side by side instead of vertically.

COMBINATION TYPES.—Windows which are combinations of the above types have names which indicate their construction. For instance, a window having a pivoted upper sash and stationary lower sash is called a pivoted upper, fixed lower sash window. A window having two sashes, both of which are pivoted, is called a double pivoted window. A window having a single pivoted sash is called a single pivoted window. A window having a top hinged upper sash and double hung lower sash is usually called a double hung window with top hinged transom, etc.

Owing to the fact that a type of window having the upper sash pivoted and the lower sash stationary, is more generally used than other types of pivoted windows, a pivoted window is now generally understood as being a two-sash

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* Issued by the Underwriters' Laboratories, Inc.

window having the upper sash pivoted and the lower sash fixed. Windows having the upper sash fixed and the lower sash pivoted, are often spoken of as reverse pivoted windows.

FRAMES AND FRAME MEMBERS.—Hollow metallic windows of any type consist of a frame and one sash or more. Frames formed with offsets or shoulders to receive masonry are called rabbeted frames. Frames not provided with rabbets are generally formed with metal wings or flanges. Flanges designed to be built into the masonry are called walling-in flanges. The frames of all windows having a single sash and the frames of sliding sash windows having two sashes are composed of two horizontal members called the head and sill, and two vertical members called the jambs.

The head is that portion of the frame which forms the top, the lower surface of the head being called the soffit and the upper surface the top of the member.

The sill is that portion of the frame which forms the bottom, and the upper surface is called the tread and the lower surface the base.

The jambs form the sides of the frame, the part in contact with masonry being called the back of the jamb and the part in contact with the sash the front of the jamb. Projections on the front of the jambs, designed to limit the movement of a movable sash, are called stops. Sliding sash windows are frequently equipped with stops which may be separated from the jamb and these separable strips are frequently spoken of as sash guide strips, the strip dividing the two sashes being frequently called the sash parting bead.

The frame of a pivoted window having two sashes is composed of the same members as the frame of a sliding sash window and an additional horizontal member which is called the transom bar.

The frame of a twin window is composed of a head sill, two jambs and a vertical division member which separates the sashes.

That part of the wall structure which divides windows from each other is called the mullion. This mullion may be an integral part of the wall structure or may be built in with the window.

SASHES AND SASH MEMBERS.—The sash is that part of the window construction which holds the glass, and may be permanently attached to the frame, in which case it is called a fixed or stationary sash, or may be so constructed that its position can be changed, in which case it is called a movable sash.

Each sash is composed of horizontal and vertical sash members.

The horizontal members at the top and bottom of the sash are called the RAILS. In sliding sash windows the rails which join each other at the middle of the window when the sashes are closed, are called the meeting rails.

The vertical members at the sides of the sash are called the STILES. In casement windows, the stiles to which the hinges are attached are called the hinge stiles, and the stiles to which the locking mechanism is attached are called the lock stiles. When casement windows are made in two parts, meeting at the middle, the stiles in contact with each other are called the meeting stiles.

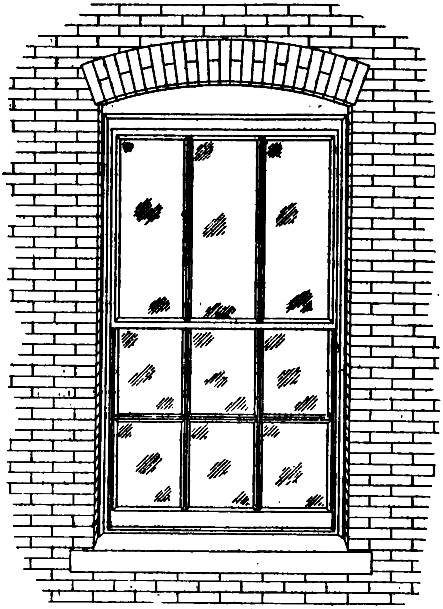
The intermediate members separating the panes of glass are called MUNTINS. If the muntin is installed in a vertical position, it is called a vertical muntin. If it is installed in a horizontal position, it is called a horizontal muntin. Muntins which are so designed that one part may be removed for glazing are called separable type muntins, and muntins which cannot be taken apart for glazing purposes are called non-separable type muntins.

NOTE.—In architecture, the word muntin is used to designate the vertical sash members dividing the lights from each other, while the horizontal members are called bars. Window manufacturers usually term these members vertical and horizontal muntins, which terms have been adopted in this guide.

The illustrations show the various members of a window and the names of the various parts, Fig. 37 showing a double hung window; Fig. 38, a pivoted window; Fig. 39, a tilting window on each side of a masonry mullion. Fig. 40 shows a twin top hinged window, the two sashes being separated by a vertical division member.

Rules Relating to Glazing

APPROVED GLASS.—Glass to be an approved make and comply with the Rules and Requirements of the National Board of Fire Underwriters as given below:



Double Hung Window Installed in Brick Wall.

Fig. 37

(a) "To have a thickness of at least ¼ inch at the thinnest point.

(b) "Wire mesh to be not larger than ⅞ inch and wire used for such mesh to be not smaller than No. 24 B. & S. gauge. The plane of the wire mesh to be practically midway between the two surfaces of the glass.

(c) "Selvage to be removed from the glass before framing."

BEARING OF GLASS IN GROOVES.—Actual bearing of glass in grooves to be at least ⅝ inch at all points.

As the maximum depth of the grooves is ¾ inch, a space of ⅛ inch is allowed between the bottom of the groove and the edge of the glass. Careful glazing is necessary to prevent one edge of the glass from resting on the bottom of the groove, thus decreasing the bearing surfaces on the opposite side. (See Figs. 47, 48, 49.)

FILLING OF GROOVES.—Glass to be set in putty and all space between glass and metal forming the sides and bottom of grooves to be well filled with the same material. Surface of putty to be flush with the top of the groove and finished smooth.

The putty joint should be made in such a manner as to prevent water from remaining in contact with the sheet metal and thus causing corrosion.

The filling of the space between the edge of the glass and the bottom of the groove with putty insures the proper spacing of the glass in the grooves.

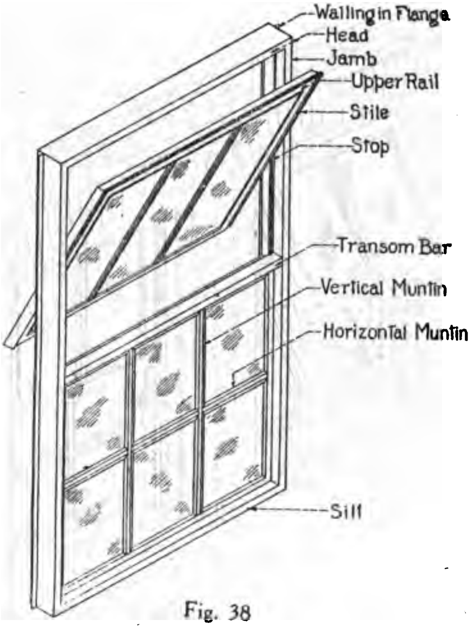


Fig. 38

Pivoted Window before Installation.

FASTENING OF SASH MEMBERS AFTER GLAZING.—All sash members removed for glazing purposes to be securely fastened in place after glazing.

Hollow metal window frames for wired glass are designed to permit reglazing by either one or the other of two methods. In the first of these methods, the glass is inserted through the top rail of each sash, necessitating the removal of the closure piece at the top of the rail and the cap piece of the groove.

The second method is used when the window is of such a design as to permit the removal and replacement of the metal forming one side of some of the grooves. The removable pieces are generally the inside parts of the muntins, although in some makes of windows the metal forming the sides of the grooves in stiles or rails may be removed from the inside of the window. The removable pieces can generally be distinguished by the exposed heads of the screws with which they are fastened. See Fig. 50 and 51.

BROKEN GLASS.—All broken glass to be replaced by unbroken lights of approved quality and dimensions.

While cracks do not materially injure the glass from a fire retardant viewpoint, provided the wire is not broken, such cracks may permit moisture to come in contact with the reinforcement and affect the fire retardant properties of the glass by corroding the wire. It is also probable that cracked glass would soon be replaced by the owners of the building where the windows are installed, and such replacement might be made by inexperienced glaziers using improper methods of installation or non-standard glass.

Rules Relating to Operation

Proper Installation of Sashes in Frames.—Sashes to be securely mounted in frames. Movable sash to operate easily and engage the stops properly.

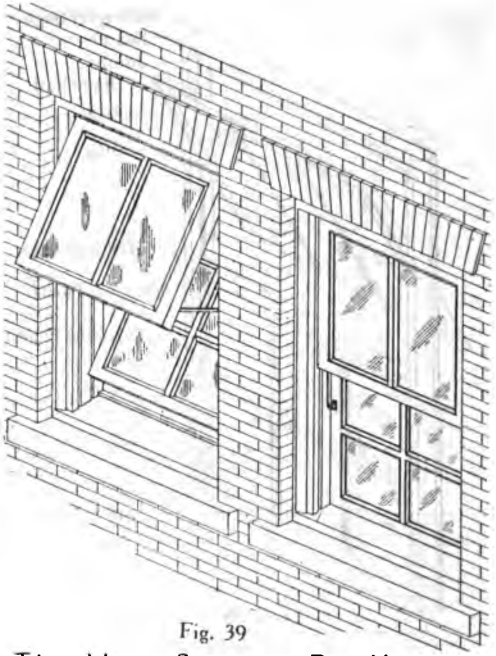


Fig. 39

Tilting Windows Separated by Brick Mullion.

Any distortion of frame or sash due to rough handling or improper installation, is liable to cause binding of the sashes in the frames and prevent easy operation and proper registration between interlocking parts. (See Figs. 52 and 53.)

Operation of Hardware.—Hinges and pivots to be so adjusted as to permit easy movement of sashes in frames.

Pulleys to operate freely and be so placed as to prevent chafing of chains or rubbing of weights against the metal forming the weight pockets.

Locking mechanism to be so placed and adjusted that the latches will engage the catches securely and easily.

While it is desirable that the latches should engage the catches easily, the fastenings should not permit excessive movement of the sash after being secured in position.

OPERATION OF AUTOMATIC DEVICES.—Action of automatic mechanism to be positive and reliable.

Locking mechanisms designed to latch automatically should be so constructed that the engagement between the latches and catches is positive when the sash closes gently and when it closes with considerable force.

Sash should close immediately upon being released by the fusing of the link, and the position of the link should be such as to insure its fusing in the event of windows being subjected to severe exposure from a fire outside the building.

It should not be possible to turn the sashes of pivoted windows to such a position that they will not close automatically.

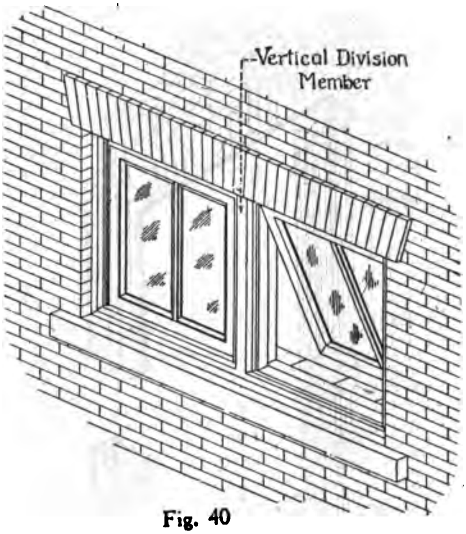


Fig. 40

Twin Hinged Windows

Suggestions Covering Methods of Inspection to be Used in Determining the Character of the Installation and Compliance with the Rules

It is desirable that window installations should be inspected as often as possible while the walls of the building are in course of construction, as compliance with the rules relating to the formation of masonry around the backs of the jambs cannot be determined except by observation at the time of erection.

In inspecting a window already installed, careful attention should be given to the character of the joint between the window and the wall structure. This joint should be made in such a manner as to prevent entrance of moisture or passage of air between the frame and masonry.

A straight-edge may be applied to all surfaces of the window in order to determine whether or not settlement of surrounding masonry has caused deflection of the frame members.

Bowing of frame members causes binding of the sash in the frame and often prevents proper action of the locking mechanism.

Masons should be cautioned not to force bricks against the window frames, as the use of excessive force in pressing the bricks into place is liable to cause distortion of the window.

The corners of the frame may be tried with a square in order to determine whether or not settlement of masonry or rough handling during installation has caused any distortion.

The sides of the frame may be tested with a plumb level or line to determine whether or not they are set vertically in the wall. This is especially important in the case of double hung windows, as rubbing of the weights would result from material misalignment of the jambs.

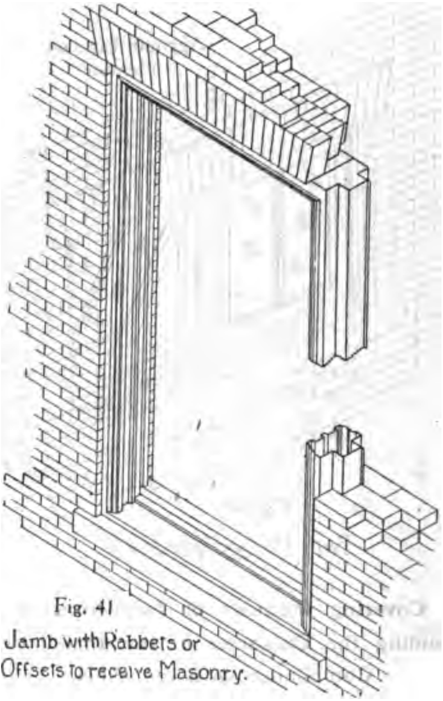


Fig. 41

Jamb with Rabbets or Offsets to receive Masonry.

A slight variation from the perpendicular in the setting of a window does not render it open to criticism unless such variation is pronounced enough to interfere with the movement of the sash. This may often be determined by operating the sash.

All frames of whatever construction should be firmly secured to the wall structure. In cases where the wall structure is of unusual character, the frames are generally made with long flanges which are designed to provide overlapping pieces which may be fastened to the wall by spikes or screws threaded into structural iron. Owing to the many different types of wall construction, a specific rule applying to each type cannot be formulated, but no installation should be approved unless the frames are securely held in place.

When windows are glazed at the factory, the factory inspection covers the glazing, and in such cases the label may be taken as evidence that the glazing is properly done. The notice of shipment states whether or not windows are glazed at the factory.

Whenever possible, windows should be inspected while glazing is in progress, as the size of the glass used, the bearing in the grooves and the filling of the grooves with putty may be checked up most easily at that time.

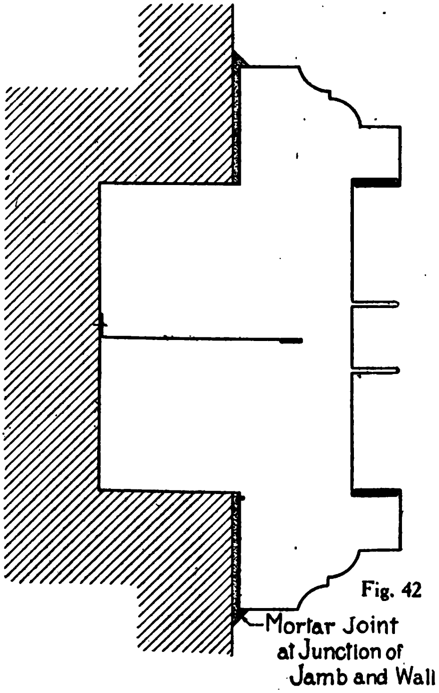


Fig. 42

In case it is impracticable to visit the building while glazing is in progress, the details regarding the fastening of sash members, the make of glass used and damaged glass may be determined by an inspection of the completed window. Other details, such as the bearing of the glass in the grooves and the completeness with which the grooves are filled with putty, may be checked by taking off the removable parts of the sash.

It is well to require the submission of sales sheets showing the size of glass provided for glazing the windows, as the dimensions of the glass furnished may not be in accordance with the dimensions furnished by the window manufacturer and checked up at factory inspection on the windows.

The inspector must use his own discretion as to the percentage of windows in a building that it will be necessary to inspect in this manner, the number depending somewhat upon the character of the workmanship shown by the first samples inspected. The window contractor should have straight-edge, square and plumb level or line available for use by the inspector.

When the windows comprising an installation are glazed through the top rail, the inspector should not attempt to remove the top closure piece and cap for the grooves, but should make an appointment with the parties responsible for the glazing in order that these removable pieces may be taken off and replaced by them.

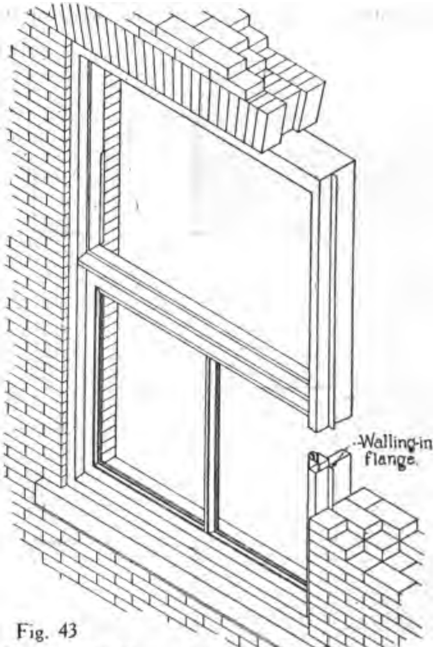


Fig. 43

Frame with Walling-in Flange.

All movable sashes should be tested to determine their freedom of operation and the sashes should be so set in the frames that they will move easily without material rubbing of parts.

The sash chains of a double hung window should be securely attached to the sashes and to the weights in the jamb.

The screws fastening the latches, catches, pivots, pulleys, etc., in place should be set tightly.

The meeting rails of double hung windows should register with each other in such a manner as to enable the locks to be operated without the use of excessive force.

The latches of pivoted windows should engage the catches when the windows are opened and allowed to fall through a distance of 6 inches, and should also engage positively when the sashes are opened fully and allowed to drop through their entire travel.

The locking mechanism of a pivoted window should not allow the sash to rebound after closing.

Pivoted windows should not be equipped with chains of sufficient length to retard the proper action of the locks.

The locking mechanism of hinged windows should be subjected to the same tests as those of pivoted windows.

Automatic devices used in connection with wired glass windows should be of such a character that their failure to operate cannot possibly interfere with the working of the sashes as manually operated devices. Inspectors should, therefore, make such tests as appear advisable in order to determine that chains released by the action of a fusible link cannot possibly fall to such a position as to prevent the window from closing.

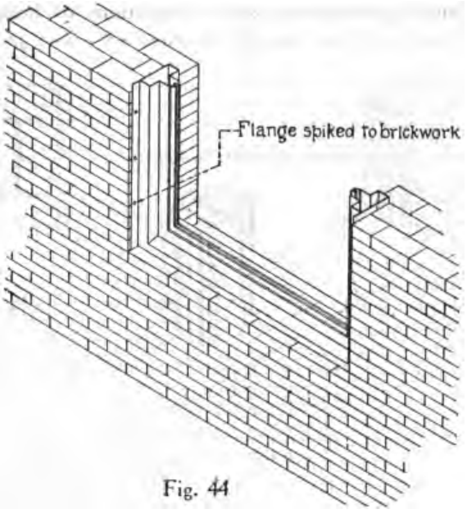


Fig. 44

Frame Installed in Old Wall Opening.

Fusible links should be so placed that they will be on the weather side of the window when the sash is opened. In inspecting windows equipped with automatic closing devices, a certain percentage of the windows should be tested as nearly as possible under actual service conditions. This is especially desirable in the case of pivoted windows. In the case of automatic mechanisms attached to double hung windows, the inspector before test should assure himself that the automatic devices may be put in good order easily, or should delay the test until a representative of the window manufacturer is present in order that the mechanisms may be put into working condition immediately after the test.

Inspectors should carefully guard against leaving automatic mechanisms in an inoperative condition as a result of inspection, and it should not be possible to place a pivoted sash in an open position from which it will not close by gravity.

PRISM GLASS FRAMES USED AS A FIRE RETARDANT*

Prisms, as installed for the purpose of increased light, are usually not contained in frames which are designed to withstand severe heat, as the requirements for strength under the different conditions of actual installation do not necessitate a frame which can be relied on as a fire retardant.

The metallic ribbons between the prisms used for the purpose of light only are not heavy enough, are not continuous and unbroken in both directions and are not attached to the metal border securely enough to withstand severe conditions of heat. The ribbons in one direction are usually formed of short pieces slipped in between the unbroken ribbons running in the opposite direction, and are held in position by solder.

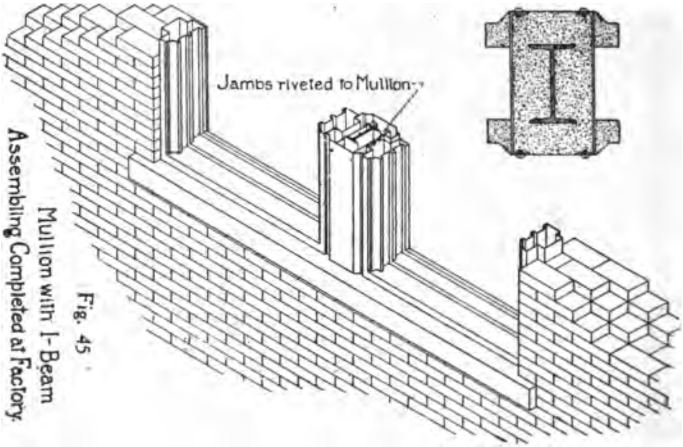


Fig. 45
Mullion with I-Beam
Assembling Completed at Factory.

In frames for this service the ribbons are usually of comparatively light metal and are fastened to the metallic border by soldering.

It has been demonstrated by fire tests that prism frames constructed as described do not possess sufficient fire resisting properties to warrant consideration. But where constructed for the purpose of withstanding severe conditions of heat they may be made of service.

In all cases where electro-glazed frames are to be installed as a protection against fire they should be specially constructed for this purpose and framed in as careful and secure a manner as wired glass.

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* Regulations of the National Board of Fire Underwriters.

The window frame and sash containing the prism glass frame to fulfill the requirements for hollow metallic or wrought iron frames for wired glass.

Size.—The dimensions of the unsupported electroglazed panel not to exceed 50 inches in either direction.

This will permit the use of standard metal frames for wired glass.

Borders.—The metal border at the edges of the electro-glazed panel to be of rolled copper or brass tubing at least ½ inch wide by ⅜ inch in thickness. The corners to be securely fastened together by substantial knees of the same metal inserted in the tubing.

Glass.—Polished plate or prism glass units not to exceed four inches in either direction and to have a thickness of at least 3/16 inch.

Ribbons.—The ribbons or metal strips between the glass units to be of unbroken strips of rolled copper, 4/32 inch in thickness and 9/32 inch in width, interlocked at each intersection. All ends to pass entirely through the borders and be clinched on the outer edge.

Electrolytic Deposit.—All joints at the corners of the border, at the fastenings of the ribbons to the border and at the intersections of ribbons to be securely fixed by a sufficient electrolytic deposit of copper to form a rigid framing, and to retain the glass units securely in place.

The border to be retained in a rabbet or groove in the sash at least ½ an inch in depth. In windows having a width of over 24 inches the border to be bolted to the upper rail of the sash.

SKYLIGHTS AND OTHER ROOF STRUCTURES

Class A—Skylights*

TYPES.—By the term skylights as considered in these rules is meant any opening through roof of building for the admission of light.

The following types with their modifications and combinations, which are included, are noted: Flat Skylights, plane or inclined; Peaked Skylights; Cupola Skylights; Monitor and Lanterns; Sawtoothed roofs; Raised Sections of roofs with vertical sash; Ventilating Skylights; Dormers, etc.; also Special Skylights as over stair, elevator or dumbwaiter shafts, and over stage portions of theaters.

Construction

1. GLASS.—(a) For all skylights, plane or inclined not over 45 degrees, to be either of standard wired glass not less than ¼ inch thick or ⅛ inch thick glass protected with approved wire screens. Panes to be not over 18 or 20 inches wide, and not to exceed 720 square inches in area.

(b) For vertical skylights or sash, or such as are inclined at an angle of over 45 degrees, may be wired glass as noted under (a), ⅛-inch thick glass without screens, or glass not less than ¼ inch thick, provided the sash or skylights are protected by suitable screens.

(c) For vertical skylights or sash, or such as are inclined at an angle of over 45 degrees, when exposed in such a manner that the wall openings in buildings would require standard fire shutters or standard wired glass (or doors) against such exposures, standard wired glass only must be used.

(d) For skylights over fireproofed stair, elevator, dumbwaiter, air or similar shafts not over ⅛ inch glass, either on top or at sides of cupola skylight, if surmounted by that type, protected by suitable screens.

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* Regulations of the National Board of Fire Underwriters.

(e) For skylights over stage sections of theaters not over ⅛ inch glass, protected by suitable screens.

NOTE.—Substitutes for glass such as wire cloth with a coating of translucent, combustible substance or similar material are not approved.

2. SASH.—(a) Materials.—Sash to be constructed entirely of metal, either galvanized iron, wrought iron or angle iron.

(b) Construction.—To be constructed with interlocking seams or rivets in accordance with the rules and requirements of the National Board of Fire Underwriters for wired glass windows.

(c) Glazing.—Glass to be secured to the sash by means of metal strips held in position by bolts or screws in such a manner as to form joints sufficiently elastic to allow for proper expansion and contraction, and to be weather proof.

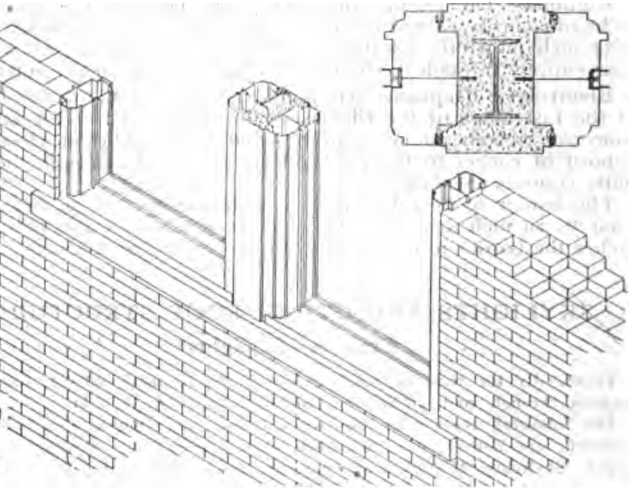

Fig. 46

Mullion Construction for I-Beams Installed at Building

3. FRAMES.—Frames for low flat or small cupola skylights to be entirely of galvanized iron secured to angle irons, all properly riveted together and securely fastened to roof. All joints to be tight and weather proof.

4. CURBS FOR SKYLIGHTS.—(a) If on buildings of fireproof construction, to be constructed of approved fire-proof materials reinforced with angle iron properly protected by approved fire-proof material.

(b) If on buildings of slow-burning construction, may be either (1) of not less than 4 x 4-inch framework, filled in with brick, terra cotta, cement or other approved fire-proof materials, tin-clad on the outside; (2) double boarded, tongued and grooved, boards at right angles to each other, tin-clad on the outside; (3) of not less than 2¾-inch tongued and grooved, or splined plank, tin-clad on the outside.

(c) On all other buildings, if not in accordance with the foregoing, to be thoroughly tin-clad on the outside.

(d) Curbs must be securely fastened to framework of roof, and when on roofs of joisted construction must be supported on doubled joists.

5. MONITOR OR LANTERN SKYLIGHTS.—(a) Construction.—To conform in general with roof construction of buildings of which they form a part, and as specifically noted under Curbs, section 4, class A.

(b) Sash.—To conform in all particulars to sections 1 and 2, class A.

(c) Frames.—(1) If for skylights on tops of monitors or lanterns to conform with section 3, class A. (2) If in sides of monitors or lanterns of fire-proof construction to be constructed in accordance with the requirements for Wired Glass Windows, page 244. (3) For all monitors or lanterns where woodwork is permissible, see under (a), this section, the frames, if of wood, must be thoroughly protected by galvanized iron, including the rabbets, if any, or recessed portions, receiving the sash.

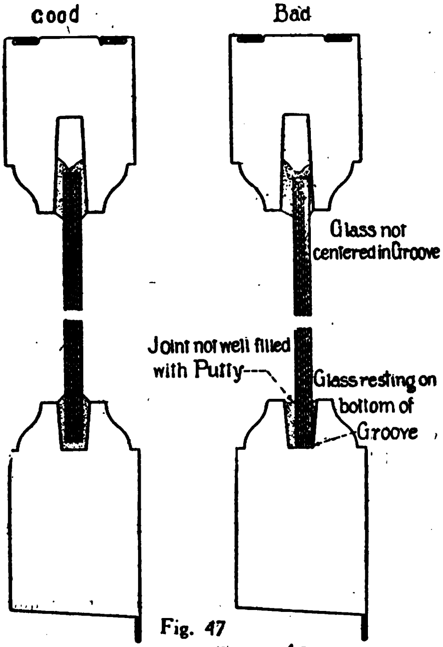
Good
Bad
Glass not centered in Groove
Joint not well filled with Putty
Glass resting on bottom of Groove

Fig. 47

Section of Rails showing Proper & Improper Glazing

6. SAWTOOTHED SKYLIGHTS.—(a) Construction.—To conform in general with roof construction of buildings of which they form a part, and as specifically noted under Curbs, section 4, class A.

(b) Sash.—To conform in all particulars with sections 1 and 2, class A.

NOTE.—Usually this type of skylight is one continuous frame. The muntins or rails must conform in manner of construction and securing to the requirements of the National Board of Fire Underwriters for the construction of frames for wired glass. Any deviations of this arrangement will be governed by the rules or requirements of the types or kinds under which they may come.

7. VERTICAL SASH UNDER RAISED SECTIONS OF ROOFS.—This includes also a row of sash or sections of wall entirely of glass, above the wall proper and underneath the roof.

Must conform in general with the rules and requirements noted under sections 5 and 6, class A, in so far as these apply.

8. VENTILATING SKYLIGHTS OR SKYLIGHT SASH.—Frequently portions of skylights (sometimes the entire sash) are arranged that they may be opened for purposes of ventilation; if top sash are so arranged they are generally hinged at the highest point, while side sash are hinged either at the top, or near the center line, turning either on a horizontal or vertical axis. Sash hung at the top are usually secured by hinges, those hung near the central line by trunnions or pivots.

(a) Hinged and Pivoted Sash.—To be provided with hardware, and hung and arranged in such a manner as to conform to the requirements for the construction of frames for wired glass.

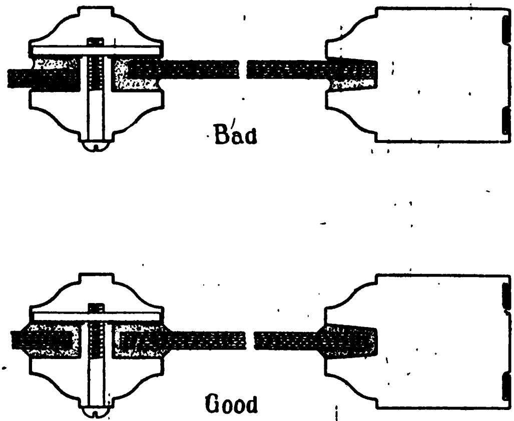

Fig. 48

Sections of Stiles and Muntins Showing Improper and Proper Glazing.

(b) Protection.—All ventilating skylights or skylight sash must be protected by wire cloth screens as specified, in such a manner that the screen will allow full freedom of operation. In no case must the operation of the sash require the removal of the screen or any portion of same. The screens should be entirely independent of this type of skylights or sash and shall be of ample size to completely protect the opening.

9. WINDOWS IN ROOF STRUCTURES.—All window openings in roof structures, such as shafts extending above roofs, pent houses, high curbs, ends of sawtoothed or monitor or lantern sklights, etc., must conform to sections 1, 2 and 5, class A, in so far as these apply.

10. DORMER WINDOWS.—(a) Construction.—To conform in general with roof construction of buildings of which they form a part, and as specifically noted under Curbs, section 4, class A.

(b) Sash and Frames.—To conform in all particulars to sections 1 and 2 and section 5, class A, respectively, in so far as these apply.

11. **SKYLIGHTS ON STAIR, ELEVATOR, DUMBWAITER, LIGHT, AIR and similar shafts, if of fire-proof construction and cut off at floors.**

(a) Construction.—To be constructed with metal frames and sash in accordance with sections 3 and 2, class A.

(b) Glazing.—Top sash of cupola skylights, if any, to be glazed with wired glass, or ½ inch thick glass protected, see section 1, class A, sides should be glazed with glass not over ⅛ inch thick; plane skylights to be glazed with glass not over ⅛ inch thick; protected by suitable wire screens. Glazing to be done in accordance with section 2, class A.

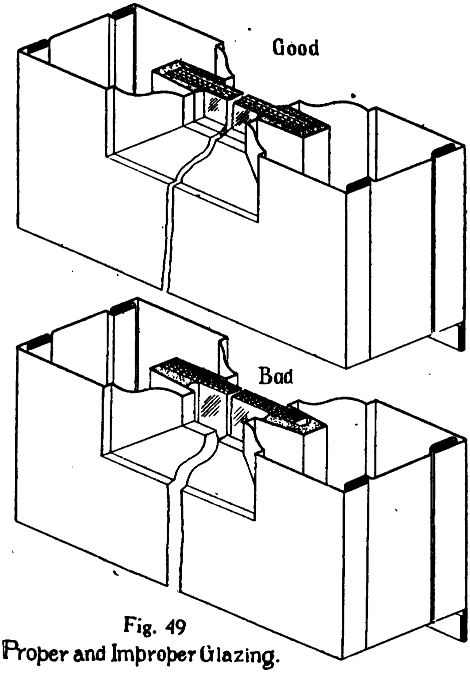

Fig. 49
Proper and Improper Glazing.

(c) Ventilation.—Where ridge ventilators, or louvers in ends or sides of such skylights are provided, these must be protected by suitable wire cloth screens, properly secured.

12. THEATER STAGE SKYLIGHTS.—(a) Construction.—Curb or frame, and sash to be constructed in accordance with the rules and requirements of sections 2, 3 and 4, class A.

(b) Glazing.—To be glazed with glass not over ⅛ inch thick, in accordance with section 2, class A, each pane measuring not less than 300 square inches.

(c) Operating.—Sash to be in two movable sections, so arranged as to be opened readily by the action of heat from below on a fusible link or series of links; or similar device, which upon parting will allow the sash to open automatically, and also by means of the cutting of a hempen cord, extending to the stage floor and within reach of fly gallery.

(d) Types.—Two types of skylights for this purpose are suggested.

(1) Two counterbalanced sash, hinged to the outer edges of the curbing or frame, which should be slightly hip shaped, the upper edges coming together when the sash are closed, and arranged in such a manner that one is provided with an overhanging lip or batten to keep out the weather. Each sash to have extension rods or bars at the lower (hinged) edge, projecting beyond the curb for a distance not less than the width of the sash, to which bars should be securely attached a weight not less than 50 per cent heavier than the weight of the sash. Hinges to be of heavy brass, bolted to the sash and curb or frame, and set well back from the edges of the frame.

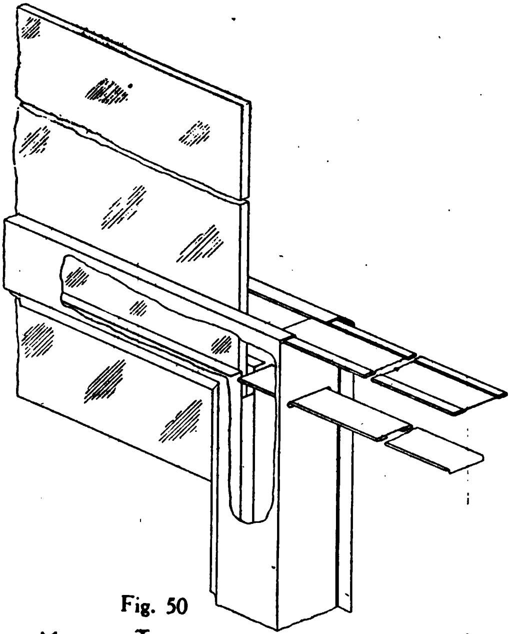

Fig. 50

Method of Inserting Glass through Top Rail.

(2) Two rolling sash, fitted with brass wheels not less than 2½ inches in diameter, set inside of outer edge of sash for a distance of not less than 2 inches, well secured to sash. The wheels to roll on brass tracks properly secured to the curb or frame and rails extending beyond same on either side to roof. Curb or frame to be hip shaped, the slopes to be such that the sash shall be inclined at not less than an angle of 30 degrees.

The height of the curb or frame shall be such that the lowest portion of the tracks on which the sash slide, shall not be less than 12 inches above the roof.

(e) Protection.—Either type of skylight for this purpose shall be protected by suitable steel wire cloth, properly secured in such a manner as not to interfere with the operation of the sash and of sufficient size to cover the entire opening properly, as well as to protect the sash when open.

Protection

All skylights, except those glazed with wired glass, or glass ½ inch thick or over, when inclined at an angle of over 45 degrees or vertical (unless exposed as noted under section 1, rule c, class A) should be protected by wire screens of galvanized steel wire cloth.

13. WIRE CLOTH.—(a) Kind.—All wire cloth shall be woven (not twisted) of steel wire, galvanized after weaving.

(b) Sizes.—(1) For plane skylights, or skylights inclined at an angle of 45 degrees or less (unless glazed with wired glass), cloth of not lighter than No. 12 wire and not over 1-inch mesh shall be used.

(2) For vertical skylights or sash, or such as are inclined at an angle of over 45 degrees, with wired glass or glass not less than ½ inch thick, unless exposed (see class A, rule 1, section c), cloth of not lighter than No. 12 wire and not over 1-inch mesh shall be used.

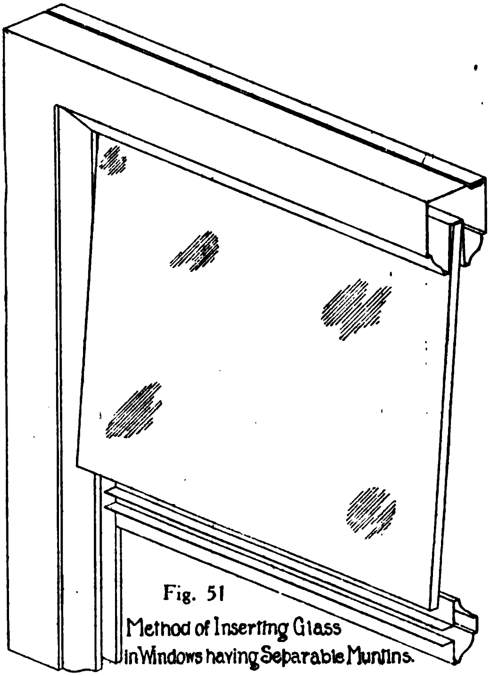

Fig. 51
Method of Inserting Glass in Windows having Separable Muntins.

(3) For all ventilating skylights, or hinged or pivoted or sliding sash, care must be taken that opening is thoroughly protected against the ingress of sparks.

14. SECURING WIRE CLOTH.—All wire cloth shall be securely fastened to frames by means of galvanized iron wire or by means of special metal strips and rivets, bolts or screws.

15. FRAMES.—(a) Materials.—Frames for wire cloth screens shall be constructed of iron rods, pipes or angles as follows: (1) For screens not over

3 feet in any direction, ⅜-inch rods, ¼-inch pipe or ½-inch angles. (2) For screens over 3 feet and under 4 feet in any direction, ½-inch rods, ⅜-inch pipe or ¾-inch angles. (3) For screens over 4 feet and under 6 feet in any direction, ⅝-inch rods, ¾-inch pipe or 1-inch angles. (4) For screens over 6 feet and under 10 feet in any direction, 1-inch rods, 1¼-inch pipes or 1½-inch angles. (5) For screens of larger sizes, proportionately larger sized materials shall be used, in which case angles are to be preferred.

(b) Reinforcing.—Where dimensions exceed 3 feet in any direction, cross bars, placed not over 3 feet apart, or over 3 feet distant from outer bars, shall be provided for reinforcing the frames. These reinforcing bars shall conform in size to the rods, pipes or angles under (a), this section, increasing in size as noted according to span.

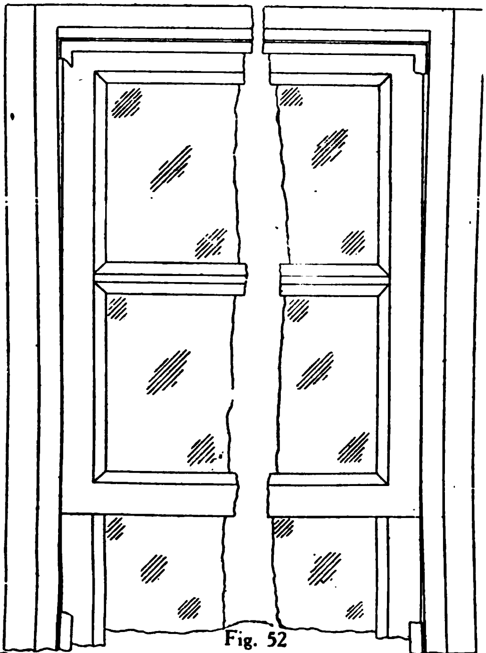

Fig. 52

Binding of Sash in Frame Caused by Distortion of Jambs.

(c) Supports.—Upright supports, to correspond with materials specified under (a), this section, and at end of each reinforcing member, and to be not less in size than the bars supported.

(d) Braces.—All enclosing frames over 3 feet high and more than 6 feet in length shall have braces extending from the upper angles to the base line, one in each corner of each side.

(e) Construction.—The frames should be strongly assembled.

(1) If constructed of rods these should be welded together, or threaded and securely joined by threaded malleable iron fittings, and upright members shall be properly shaped at lower ends to permit fastening by means of

screws; or if size permits, to be threaded and provided with threaded malleable iron base or foot plates drilled for three bolts or screws each.

(2) If constructed of pipes, these should be threaded and secured by means of threaded malleable iron fittings, and upright members shall be threaded and provided with threaded malleable iron base or foot plates, drilled for three bolts or screws each.

(3) If constructed of angle irons these should be welded together or fastened at the corners by fillet angles securely riveted in place. Upright members shall be shaped at base to permit fastening by at least four screws or bolts each.

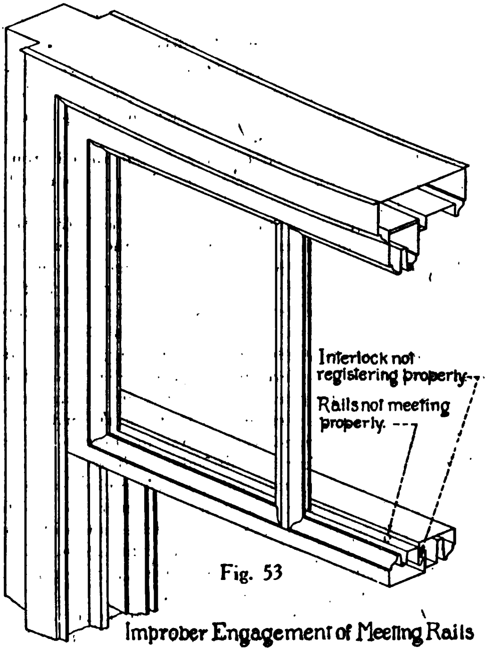
Interlock not registering properly
Rails not meeting properly

Fig. 53

Improper Engagement of Meeting Rails Caused by Deflection of Head

(f) Securing Frames.—All frames for screens to be secured to roofs or frames of permanent skylights, monitors, lanterns, etc., by means of lag screws or bolts.

16. DISTANCE OF SCREENS FROM SKYLIGHTS, ETC., TO BE PROTECTED.—(a) All screens shall be placed 6 inches or over above skylights to be protected, and shall project the same distance beyond edges of skylights as raised above them.

(b) All screens used for protecting side lights shall be placed not less than 6 inches from lights or openings so protected.

17. RAISED SKYLIGHTS.—Screens for raised skylights having top and side sash contiguous shall have the frames on top secured to those on the sides as noted under (e), section 15, and wire cloth shall cover the entire framework and come within 6 inches of roof.

18. VERTICAL OR SAWTOOTHED SKYLIGHTS OR SASH, OR THOSE INCLINED AT AN ANGLE OF OVER 45 DEGREES.—Screens for vertical or sawtoothed skylights or sash, or those inclined at an angle of over 45 degrees, shall be turned in at the top and sides in such a manner as to exclude embers or sparks from space between the screens and glass.

19. REMOVABLE SCREENS.—Where for any purpose it becomes necessary that screens or portions of screens used in protecting side lights must be removable, these screens or portions of screens shall be framed as specified under section 15, and similarly constructed frames placed around such openings. Such screens or sections of screens shall be secured to the permanent frame by means of riveted wrought iron hinges and be provided with strong wrought iron latches, bolts or hooks.

Class B—Ventilators

TYPES.—By ventilators, as considered in these rules, are meant all structures designed for the emission of air, gases or vapors from the building, separate rooms or compartments, and include louver openings as well as ridge ventilators on tops of skylights.

20. MATERIALS.—To be constructed entirely of galvanized iron at least No. 24 gauge, copper at least No. 20 gauge, or of other approved fire-resistive materials.

21. CONSTRUCTION AND PROTECTION OF VENTILATORS.—(a) If flues, either extending through roofs or sides of buildings, these should be provided either (1) with cowls or hoods projecting the same distance beyond outer edge of flue that they are raised above same, but in no instance less than 3 inches, and opening must be protected with a screen of galvanized steel wire cloth, of not less than No. 16 wire or more than No. 3 (1/3 inch) mesh, properly secured and completely covering the opening; or (2) edges of cowls may be carried beyond and underneath projecting or flanged edges of the flues in such a manner as to provide two turns in passage of opening; or (3) flue may be bent in such a manner as to form an inverted U.

(b) Louver ventilators, or ridge ventilators, or louvers in raised or hip skylights, shall be constructed entirely of galvanized iron of at least No. 24 gauge or copper at least 20 gauge, as specified under section 3, class A. Slats of louvers to be of galvanized iron or copper as specified, properly reinforced, and riveted to the frames. All such ventilating openings shall be protected with a screen of galvanized steel wire cloth, of not less than No. 16 wire or more than No. 3 (1/3 inch mesh), properly secured to the frames and completely covering the openings.

(c) Ventilating Monitors or similar structures, to conform in general with roof construction of buildings of which they form a part, and as specifically noted under section 4, class A. Louver or ventilating slats to be of galvanized iron or copper, as specified, properly reinforced and riveted to frames. All such ventilating openings to be protected by galvanized steel wire cloth, of not less than No. 16 wire or more than No. 3 (1/3 inch) mesh, properly secured and completely covering the openings.

(d) Frame Ventilating Structures, similar to those referred to under a, b and c, section 21, class B, but constructed of other materials, shall be protected by galvanized steel wire cloth of not less than No. 16 wire or more than No. 3 (1/3 inch) mesh, properly secured and completely covering the opening.

Class C—Door Landings, Pent Houses or Bulkheads

22. (a) On all buildings of fireproof construction to be constructed of approved fireproof materials, reinforced with angle iron, properly protected by

approved fireproof materials. DOORS to be standard. WINDOWS to be of standard wired glass, in standard metal frames.

(b) On buildings of slow-burning construction may be either (1) of not less than 4 x 4-inch framework, filled in with brick, terra cotta, cement or other approved fireperoof materials, tin-clad on the outside; (2) double boarded, tongued and grooved, boards at right angles to each other, tin-clad on the outside; (3) of not less than 2¾-inch tongued and grooved, or splined plank, tin-clad on the outside. DOORS to be double battened, tin-clad on the outside, with tinning re-turned over the edges. WINDOWS to be of standard wired glass in standard metal frames or as noted under b and c, section 1; b, section 13, and section 18, class A.

(c) On all other buildings, if not in accordance with the foregoing, and of frame, to be thoroughly tin-clad on the outside. DOORS to be tin-clad on the outside and WINDOWS protected as noted under b and c, section 1; b, section 13; and section 18, class A.

Class D—Scuttles

23. CONSTRUCTION.—(a) If on buildings of fireproof construction to be of (1) No. 12 gauge sheet iron or steel, reinforced by 2 x 2 x ¼-inch angle iron, or (2) double battened wood, standard tin-clad on all sides, edges and in all angles, and be provided with proper chafing plates where fitting over combing.

(b) If on buildings of slow-burning construction to be as noted under (a), this section, or of double battened wood, tin-clad on the outside, the tinning to return over the lower edges.

(c) On other buildings, if not in accordance with the foregoing, to be thoroughly tin-clad on the outside, the tinning to return over the lower edges.

24. FASTENING.—All scuttles are to be fastened by means of strong steel or wrought iron, galvanized hinges, bolted to scuttle and combing or roof.

25. STOPS.—All scuttles to be provided with suitable stops, consisting preferably of a strong chain, bolted to scuttle and combing, allowing the scuttle to open slightly beyond a vertical position.

26. LADDERS.—Permanent ladders should be provided, giving access to scuttles.

Class E—Open Air or Light Shafts

27. LIGHTS.—All lights at bottoms of open shafts or wells, if not of thick glass prisms set in substantial cast-iron frames, shall be in accordance with sections 1, 2, 3 (or 4), 13 (provided wired glass not less than 1/3 inch thick and no wire cloth of less than No. 12 wire or over 1-inch mesh be used), 14, 15 and 16, class A, and furthermore conform to the rules governing other types of skylights as noted under class A if such types of lights are used.

28. PROTECTION OF SHAFTS.—The tops of all open shafts shall be covered by galvanized steel wire cloth screens of not less than No. 12 wire nor over 1-inch mesh, constructed and secured in accordance with section 15, class A.

THE PROTECTION OF MAIN BELT DRIVES WITH FIRE RETARDANT PARTITIONS*

The importance of safeguarding stairways by placing them in towers well cut off from the remainder of the building and of protecting the openings made by elevators through the floors has long been recognized. Today more than formerly, these features are taken care of in the design of manufacturing buildings, including also well arranged towers for the main belts or ropes where this method of driving is employed. Fig. 54 shows how these features may be taken care of in a textile mill.

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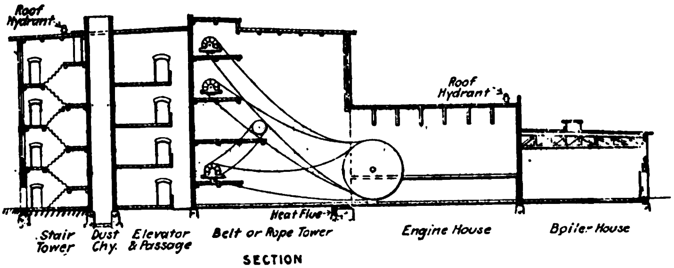
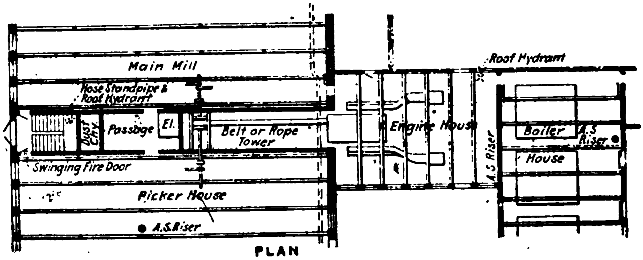
* Journal of the American Society of Mechanical Engineers, by C. H. Smith.

The following remarks apply more particularly to the older manufacturing buildings and to those of more recent construction where the best principles of design of stair and elevator towers and belt and ropeways have not been followed. Neglect to safeguard vertical openings through floors has resulted in serious loss of life among occupants of the building, who found themselves cut off from their accustomed exists by the rapid spread of fire up through such unprotected openings.



SECTION



PLAN

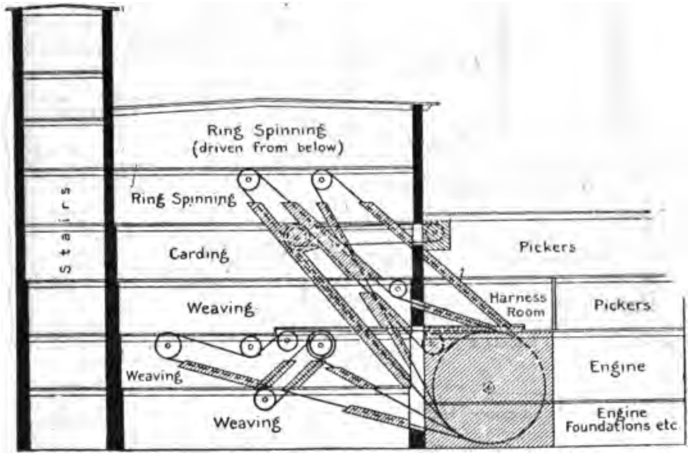
BELT, STAIRWAY AND ELEVATOR TOWERS

FIG. 54

In mills insured with the Mutual companies stairs and elevators have generally been well arranged, and the fire protective devices such as automatic sprinkler systems, etc., have shown their value not only in reducing the loss of property by fire to a minimum, but also it has been demonstrated that approved construction, high standards of general order and neatness and efficient fire protection works as well to safeguard the lives of operatives employed.

At the present time there are approximately 1,500,000 people employed in the 2800 industrial works insured with the Mutual companies, located in 29 states of the Union and Canada. Since the inception of the system in 1835, there have been but 32 deaths caused directly by fires in these properties and 21 were in a fire in an unsprinklered mill in 1876 before sprinklers were in general use. This would indicate that under present conditions, the loss of life would average less than 1 per year per 1,000,000.

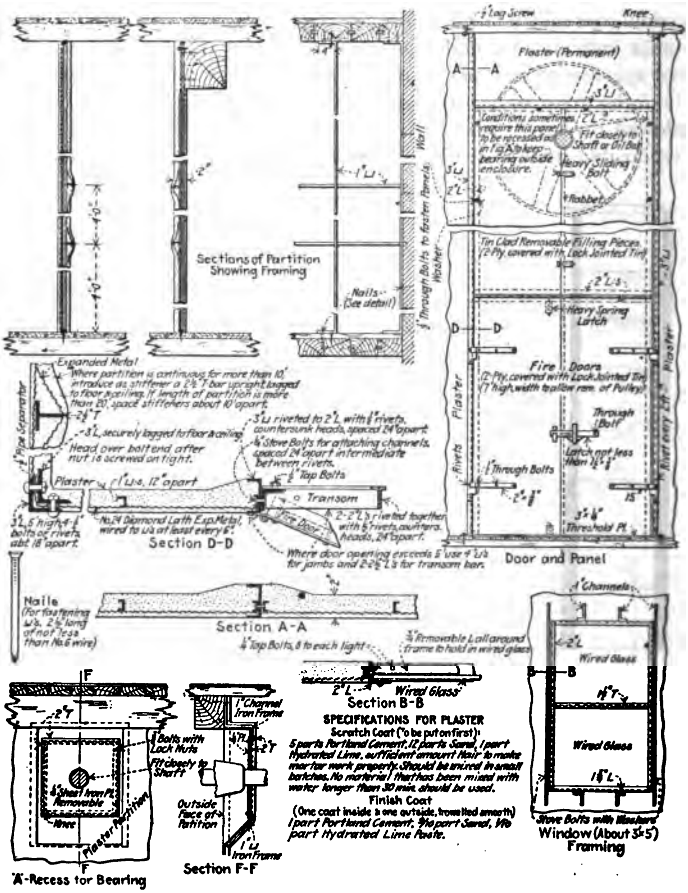
Of the total of 32 lives lost, poorly constructed beltways which allowed the rapid spread of smoke and flame were to a large extent responsible for the deaths of 25 persons. The need of safeguarding the vertical openings through floors around the main driving belts had been less fully appreciated. Conditions at these drives were aggravated moreover, because it was the general custom to enclose the belts with boxes of wood, which in some cases were about head high and in others extended to the ceiling. The boxes tended to become oil soaked and to accumulate lint. A fire once starting at or near them would rapidly make headway, being carried by the natural draft up through the mill. Such a fire would also be more or less sheltered from the action of the sprinklers in the room.



SECTION SHOWING BELTS AND WOODEN BOXING BEFORE FIRE OF SEPTEMBER 15. 1907

FIG. 55

The recurrence of several large property losses from this source led to consideration of this matter and measures were taken which have to a great extent eliminated the open beltway hazard from Mutual risks. In the experience of these companies there have been about 20 fires occurring in the vicinity of main drives in which the open beltway was an important factor in the spread of the fire. These 20 fires resulted in a total loss of $2,721,635, an average of $136,082 per fire. Some of the larger of these losses occurred in the days before sprinkler protection was as complete as now, but the statistics showed that even with complete protection the open beltway was a serious hazard.

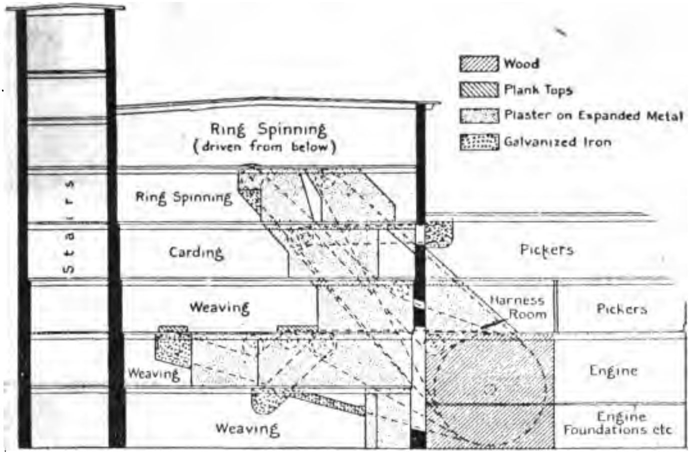

Sections of Partition Showing Framing
4'-0"
4'-0"
2"
1" ⊔
Nails (See detail)
Wall
¾" Through Bolts to fasten Panels
Washer
Expanded Metal
Where partition is continuous for more than 10' introduce as stiffener a 2½" T bar upright lagged to floor & ceiling. If length of partition is more than 20', space stiffeners about 10' apart.
2½" T
3" L, securely lagged to floor & ceiling
½" Pipe Separator
Head over bolt end after nut is screwed on tight.
3" ⊔ riveted to 2" L with ⅜" rivets, countersunk heads, spaced 24" apart
¼" Stove Bolts for attaching channels, spaced 24" apart intermediate between rivets.
½" Tap Bolts
Plaster
1" ⊔'s, 12" apart
Transom
Fire Door
3" L, 5" high, 4-½" bolts or rivets abt 18" apart
No. 24 Diamond Lath Exp. Metal, wired to ⊔'s at least every 6"
Section D-D
2-2" L's riveted together with ⅜" rivets, countersunk heads, 24" apart.
Where door opening exceeds 5' use 4" ⊔'s for jambs and 2-2½" L's for transom bar.
Nails (For fastening ⊔'s, 2½" long of not less than No. 6 wire)
Section A-A
¼" Tap Bolts, 8 to each light
¾" Removable L all around frame to hold in wired glass
2" L
Wired Glass
Section B-B
SPECIFICATIONS FOR PLASTER
Scratch Coat (To be put on first):
5 parts Portland Cement, 12 parts Sand, 1 part Hydrated Lime, sufficient amount Hair to make mortar work properly. Should be mixed in small batches. No material that has been mixed with water longer than 30 min. should be used.
Finish Coat
(One coat inside & one outside, trowelled smooth)
1 part Portland Cement, 9/10 part Sand, 1/10 part Hydrated Lime Paste.
⅜" Lag Screw
Knee
Plaster (Permanent)
A—A
3" ⊔
Conditions sometimes require this panel to be recessed as in Fig. A to keep bearing outside enclosure.
2" L
Fit closely to Shaft or Oil Bath
Heavy Sliding Bolt
Rabbet
3" ⊔
2" L
Tin Clad Removable Filling Pieces (2 Ply, covered with Lock Jointed Tin)
2" L's
Heavy Spring Latch
D—D
Fire Doors (2 Ply, covered with Lock Jointed Tin) (7' high, width to allow rem. of Pulley)
Through Bolt
Latch not less than 1½" × ⅜"
Plaster
Rivets
½" Through Bolts
2" × ⅜"
15"
3" × ⅜"
Threshold Pl.
Rivet every 1'6"
Plaster
3" ⊔
Door and Panel
4" Channels
2" L
Wired Glass
B—B
1½" T
Wired Glass
1½" L
Stove Bolts with Washers
Window (About 3' × 5') Framing
F
2" T
Bolts with Lock Nuts
Fit closely to Shaft
¼" Sheet Iron Pl. Removable
Knee
Plaster Partition
F
A-Recess for Bearing
1" Channel Iron Frame
2" T
Outside Face of Partition
1" ⊔ Iron Frame
Section F-F

Details of Construction for Fire Retardant Belt Enclosures

FIG. 56

The last bad fire from this source occurred September 15, 1907, at a cotton manufacturing establishment in Fall River. This is a stone mill, 339 ft. long, 74 ft. wide and five stories and basement in height with a 4-story wing, 94 ft. long and 65 ft. wide, projecting from the rear at the center of the mill. The engine room was located in the first story of this wing. The belts were boxed with wood and most of these were cut off head high in the several stories. Fig. 55 shows the general arrangement of the drive.

Sunday forenoon a bearing in the beltway just above the fly-wheel was being repaired. While the man doing the work stated that he had no knowledge of anything that could cause the fire, it is probable that its origin was connected with his work. After completing the job he left the locality. On returning 10 minutes later, he saw fire just below where he had been at work, and gave the alarm.



SECTION SHOWING MAIN DRIVE AS NOW PROTECTED BY FIRE RETARDANT ENCLOSURES

FIG. 57.

The fire passed up through the wooden belt boxing into all stories as far as the fourth floor where the drive terminated. The mill filled with heat and smoke so rapidly that in 5 minutes no one could enter the rooms. This was in spite of 650 sprinklers which opened, but in justice to the sprinkler equipment, it should be stated that the water pressure at this mill was weak. A section about 50 ft. wide was badly burned on each side of the main drive up through the mill.

After this fire plans were worked out to enclose the main drives with partitions of a fire retardant character, so as to approximate

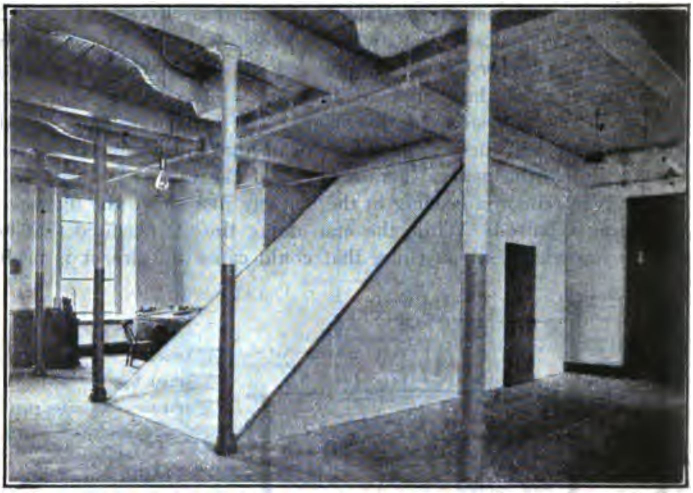


FIG. 58.—Harness Room, Second Story, Directly Over Flywheel, Showing Protection of Belts Leaving Wheel

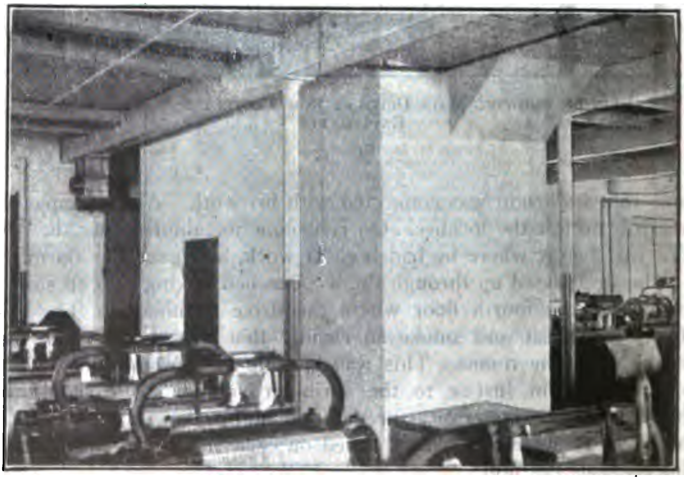


FIG. 59.—Weave Room, Second Story. Note Fire Door with Removable Panels Above to Allow Access to Pulley on Lineshaft

the standard belt tower with brick walls, such as are found in many mills of modern design.

The limitations of cost, available space, etc., which prevail in many places where the belt tower is not a part of the original design, make necessary special construction such as was adopted in this case, and has been successfully used in many others of the older mills.

The plan provided for inclosing the main drives with partitions of expanded metal and cement construction from 2 in. to 2½ in. thick depending on the story heights. A framework is constructed of expanded metal wired to 1 in. or 1¼ in. channel iron studs spaced 12 in. apart, and secured to the floor and ceiling. Longitudinal stiffeners of the same material as the studs are used. Where necessary, as in the case of a continuous partition of more than 10 ft., additional stiffness is secured by providing 2½ in. tee-bar uprights. On the frame so constructed Portland cement mortar is applied by plastering to make a solid partition, all of the iron frame being embedded in the cement with the exception of the door jambs. These partitions, being comparatively light in weight, could be set up anywhere on the heavy mill floors without the necessity of strengthening them, although where possible it was arranged to have the partitions come over the beams. Although this form of construction for partitions has been largely used and with satisfaction, it would be possible of course to employ some of the special forms of studding now on the market which combine the studs and lathing in one sheet of metal. Details of the construction used are shown in Fig. 56.

While in general the enclosures occupy only the floor space necessary for the main belts, it was endeavored to have them as roomy as conditions of machinery installation would permit, in order to facilitate inspection and repairs to the main belts. Provision was made for taking down the lineshafting without disturbing the body of the partitions, usually by placing the fire doors which gave access to the enclosure under the lineshaft, and providing removable wood tin-clad panels constructed like fire doors above the latter. The main bearings were generally left outside the enclosures and to accomplish this the panels in front of the pulleys were sometimes recessed.

It was also the endeavor to arrange these enclosures so that they would be as well lighted as possible by including in them windows in the side wall of the building or providing wired glass windows in metal frames to admit light to the beltway from the room. Fig. 57 shows diagrammatically the completed work at the Fall River mill, and Figs. 58, 59, 60 and 61 are photographs of belt enclosures in different stories. The adaptability of the construction is evidenced

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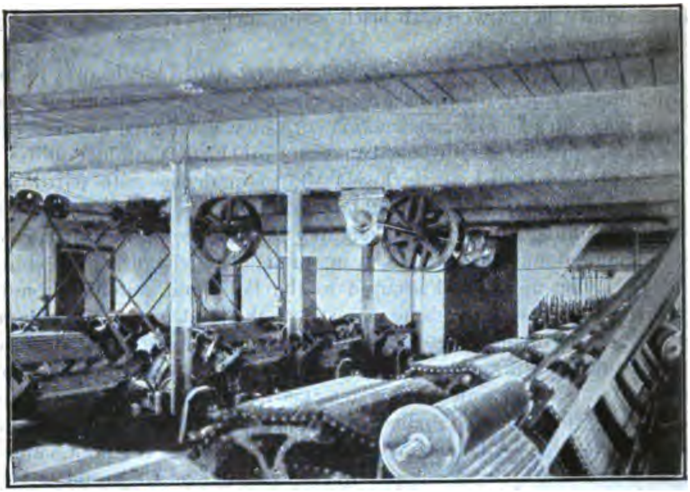

FIG. 60.—Card Room, Third Story. Ends Sloped to Economize Space. Note Wire Glass Window and Fire Door with Removable Panels Above

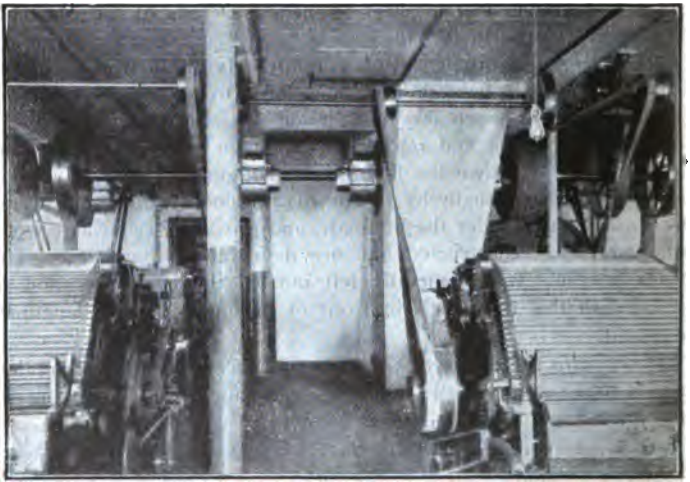

FIG. 61.—Card Room, Third Story. End View of Belt Enclosure. Bearings All Outside

in the sloping sides and offsets which it was necessary to make in many cases on account of crowded conditions in the vicinity of the main belts.

While there is no claim that these partitions are as efficient in withstanding the action of a severe fire as a brick wall would be, they are undoubtedly effective in preventing the dangerous draft up through an open beltway. In an actual fire in one of the mills where this construction was installed these enclosures were successful in confining the fire to narrow limits, and undoubtedly prevented a very serious loss.

WOODEN BEAMS AND COLUMNS

The following text and tables relating to wooden beams and columns are reprinted by permission, from "Cambria Steel," a handbook of information relating to structural steel, prepared and compiled by George E. Thackray, C. E., structural engineer, Cambria Steel Company.

The results of a series of studies of wooden beams and columns of various kinds of American timber are contained in the Proceedings of the Fifth Annual Convention of the Association of Railway Superintendents of Bridges and Buildings, October, 1895, at which the Committee on Strength of Bridge and Trestle Timbers presented a report, portions of which have been used in preparing certain of the tables on the following pages, but as noted thereon the arrangement and values in many cases have been modified by later information from various sources.

The publications of the Forestry Division of the United States Department of Agriculture, Bulletins Nos. 8 and 12, and Circular No. 15, contain reports of tests of American woods, and deductions drawn therefrom. Extracts and tables from these reports are given on the following pages.

The tables of safe loads for wooden beams and table of strength of wooden columns, given on the following pages, have been specially calculated for this book, using the information regarding the properties of the various species contained in the reports above referred to, as modified in some cases by later data.

Explanation of the Tables of Safe Loads in Pounds, Uniformly Distributed for Rectangular Wooden Beams One Inch Thick, Pages 450 to 455 Inclusive.—General.—For convenience in use, three of these tables have been prepared, from which the safe loads of the various species can be obtained, either directly or by proportion as stated in the footnotes.

The values given in the tables are the safe loads in pounds uniformly distributed. including the weight of the beam itself, for rectangular beams one inch thick for spans from four to forty feet and for depths from four to twenty-four inches. The safe load for a beam of any thickness may be found by multiplying the values given in the tables by the thickness of the beam in inches.

The last column of each of the three Tables of Safe Loads for Rectangular Wooden Beams gives a coefficient of deflection, by means of which the deflection for any beam may be obtained, corresponding to the given span and safe load, by dividing the coefficient by the depth of the beam in inches, which will give approximately the deflection in inches under the given conditions.

In each table the deflection coefficient is given for only one species of wood, as shown, but the deflections for other species may be obtained from these by proportion as explained hereafter.

For the reason that wood has no well-defined limit or modulus of elasticity the deflections obtained by the use of the coefficients are only approximate and will vary, according to the moisture content of the wood and the character of the loading. The deflections thus obtained are, therefore, useful only as a general indication of the amount of bending to be expected under the given conditions and are not exact as in the case of materials like steel which has a well-defined limit and modulus of elasticity.

The safe loads for other species of woods than those stated in the headings of the tables may be obtained from those given, by direct proportion, dependent upon the ratio of their allowable unit stress as compared with that for which the table is figured, as stated in the footnotes at the bottom of the tables.

Explanation of the Table of Safe Loads for Rectangular Beams of White Pine, Cedar, Spruce or Eastern Fir.—The values for the various species of woods, which are included in this table, are calculated for an allowable fibre stress, for flexure, of 700 pounds per square inch.

The deflection coefficients are given for white pine, and are based upon a modulus of elasticity of 1,000,000 pounds per square inch.

The lower dotted line crossing the table indicates the limits of spans for which the deflection will exceed 1-360 of the span for the kind of wood for which the deflection coefficient is given. For spans below the line the safe loads given in the tables will produce a deflection greater than 1-360 of the span, while those above the line will produce less than this, which is the usual limit of deflection, in order to prevent cracking of plastered ceilings. Similarly, the upper dotted line indicates the limit of deflection for the kind of wood for which the deflection coefficients is given, corresponding to a modulus of elasticity of 500,000 pounds per square inch, which should be considered in cases where the deflection should be more closely limited.

The coefficients of deflection for Cedar corresponding to moduli of 700,000 and 350,000 may be obtained by multiplying those of the table by 10-7 and 20-7 respectively, and Spruce and Eastern Fir corresponding to moduli of 1,200,000 and 600,000 by multiplying those of the table by 5-6 and 5-3 respectively.

The full zig-zag line in the table gives the limits of the safe loads corresponding to the allowable shearing stress along the neutral axis of the beam. The safe loads above the line, which are based upon the extreme fibre strains, will produce shearing stresses along the axis or with the grain in excess of that allowable, which, in the case of White Pine and the other woods of this table, is 100 pounds per square inch.

The position of this line, which indicates the limit of safe loads for shearing along the neutral axis, was determined by the aid of the following formula:

$$W = \frac{4bds}{3}$$

in which

W = safe load in pounds uniformly distributed.
d = depth of beam in inches.
b = breadth of beam in inches.
s = allowable shear in the direction of the grain in pounds per square inch.

Explanation of the Table of Safe Loads for Rectangular Beams of Short-leaf Yellow Pine.—The table is calculated for an allowable fibre stress, for flexure, of 1,000 pounds per square inch.

The deflection coefficients are figured for a modulus of elasticity of 1,200,000 pounds per square inch, but may be used for other moduli, after obtaining the corresponding coefficients by proportion as heretofore explained.

The lower dotted line across the table indicates the limits of spans for which the safe load will produce deflections greater than 1-360 of the length of the beam. Values above the line will give less deflection than this, and those below will give greater, based on a modulus of 1,200,000 pounds per square inch. Similarly, the upper dotted line indicates the limit of deflection corresponding to a modulus of elasticity of 600,000 pounds per square inch.

The full zig-zag line across the table indicates the limiting spans and loads based on the allowable intensity of shearing stress along the neutral axis of the beam. The values above the full zig-zag line correspond to shearing stresses greater than the allowable stress in the direction of the grain for Short-leaf Yellow Pine, while those below the line correspond to shearing stresses less than that allowable, which, in this case, is assumed to be 100 pounds per square inch.

Explanation of Tables of Safe Loads for Rectangular Beams of White Oak and Long-leaf Yellow Pine.—This table is computed for an allowable fibre stress of 1,200 pounds per square inch, for flexure, and the deflection coefficients are calculated for a modulus of elasticity of 1,500,000 pounds per square inch.

The limit for a deflection of 1-360 of the span is indicated by the lower dotted zig-zag line on the tables, the values below which correspond to deflections greater than, and those above to deflections less than, the limiting deflections. The upper dotted zig-zag line similarly indicates the limits of deflection for a modulus of elasticity of 750,000 pounds per square inch.

The lower full zig-zag line indicates the limit of allowable shearing stress along the axis corresponding to the allowable intensity, for Yellow Pine, of 150 pounds per square inch.

Similarly, the upper full zig-zag line indicates the limits for shearing along the axis for White Oak, based on an allowable intensity of 200 pounds per square inch.

Moisture Classification.—The following statements are made in Bulletin No. 12, U. S. Department of Agriculture, Division of Forestry:

"Since the strength of timber varies very greatly with the moisture contents (see Bulletin 8 of the Forestry Division), the economical designing of such structures will necessitate their being separated into groups according to the maximum moisture contents in use.

"Class A (moisture contents, 18 per cent.).—Structures freely exposed to the weather, such as railway trestles, uncovered bridges, etc.

"Class B (moisture contents, 15 per cent.).—Structures under roof but without side shelter, freely exposed to outside air, but protected from rain, such as roof trusses of open shops and sheds, covered bridges over streams, etc.

"Class C (moisture contents, 12 per cent.).—Structures in buildings unheated, but more or less protected from outside air, such as roof trusses of barns, enclosed shops and sheds, etc.

"Class D (moisture contents, 10 per cent.).—Structures in buildings at all times protected from the outside air, heated in the winter, such as roof trusses in houses, halls, churches, etc.

"For long-leaf pine add to all the values given in the tables, except those for moduli of elasticity, tension and shearing, for Class B, 15 per cent.; for Class C, 40 per cent.; and for Class D, 55 per cent. For the other species add to these values, for Class B, 8 per cent.; for Class C, 18 per cent., and for Class D, 25 per cent."

Based upon the above classification of structures, the two following tables have been figured to facilitate calculations of allowable loads for wooden beams and columns.

PROPORTION OF THE VALUES GIVEN IN THE "TABLES OF SAFE LOADS FOR WOODEN BEAMS," PAGES 450 TO 455, INCLUSIVE, TO BE USED IN ORDER TO OBTAIN THE SAFE LOADS FOR THE VARIOUS CLASSES OF STRUCTURES REFERRED TO ABOVE

Classes	Yellow Pine	All Others
Class A	1.00	1.00
Class B	1.15	1.08
Class C	1.40	1.18
Class D	1.55	1.25

SAFETY FACTORS TO BE APPLIED TO THE VALUES GIVEN IN THE TABLE OF "STRENGTH OF SOLID WOODEN COLUMNS," PAGES 456 AND 457, IN ORDER TO OBTAIN THE SAFE LOADS FOR THE VARIOUS CLASSES OF STRUCTURES REFERRED TO ABOVE

Classes	Yellow Pine	All Others
Class A	0.20	0.20
Class B	0.23	0.22
Class C	0.28	0.24
Class D	0.31	0.25

SPECIFIC GRAVITY AND WEIGHT PER FOOT FOR VARIOUS KINDS OF TIMBER

Name of Wood	Specific Gravity	Weight per Cubic Foot	Weight per Foot, Board Measure
White Oak	0.80	49.94	4.16
White Pine	0.38	23.72	1.98
Southern Long-leaf or Georgia Yellow Pine	0.61	38.08	3.17
Douglas Fir	0.51	31.84	2.65
Short-leaf Yellow Pine	0.51	31.84	2.65
Red Pine (Norway Pine)	0.50	31.21	2.60
Spruce and Eastern Fir	0.40	24.97	2.08
Hemlock	0.40	24.97	2.08
Cypress	0.46	28.72	2.39
Cedar	0.37	23.10	1.93
Chestnut	0.66	41.20	3.43
California Redwood	0.39	24.16	2.01
California Spruce	0.40	24.97	2.08

The specific gravities and weights given above are the averages of a large number of determinations by various authorities, for woods containing less than 15 per cent. of moisture or such as are commercially known as dry timber. The weights of green or unseasoned woods will be from 20 to 40 per cent. greater than those given in the above table; as given on page 305, the Building Code of the National Board of Fire Underwriters assumes somewhat heavier weights.

SAFE UNIT STRESSES FOR TIMBER

Recommended in Bulletin No. 12, U. S. Department of Agriculture Division of Forestry

Safe Unit Stresses at 18% Moisture

Species	Modulus of Strength at Rupture per Square Inch	Modulus of Elasticity per Square Inch	Elastic Resilience per Cubic Inch	Crushing Strength Endwise per Square Inch	Crushing Strength Across the Grain per Square Inch	Tensile Strength per Square Inch	Shearing Strength per Square Inch
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Long-leaf Pine (Pinus palustris) D	1550	720000	1.30	1000	215	12000	125
Short-leaf Pine (Pinus echinata) D	1300	600000	1.30	840	215	9000	100
White Pine (Pinus strobus)	880	435000	1.00	700	147	7000	75
Norway Pine (Pinus resinosa)	1090	566000	....	760	143	......	......
Colorado Pine (Pinus ponderosa)	980	444000	....	630	180	......	......
Douglas Fir (Pseudotsuga douglasii)	1320	690000	....	880	167	......	......
Redwood (Sequoia sempervirens)	1440	226000	....	650	115	......	......
Red Cedar (Juniperus virginiana)	1000	335000	....	700	250	......	......
Bald Cypress (Taxodium distichum) D	1000	450000	1.10	675	120	6000	60
White Oak (Quercus alba) D	1200	550000	1.25	800	400	10000	200
Factor of Safety	5	2	1	5	3	1	4

The figures for the species marked "D" were obtained from experiments made by the Forestry Division, the others from various sources, chiefly the 10th Census Report, but so modified as to give results comparable with Forestry Division values. To arrive at true average values of strength multiply safe loads by factor of safety given in each column. The values for resilience and tensile strength are the ultimate values. The former is practically never used in designing. The latter is a factor impossible to develop in practice, since the piece will always fail in some other way, usually by shearing.

The crushing strength across the grain in above is based upon a crushing of 3 per cent. of the cross sectional height of the piece.

AVERAGE ULTIMATE BREAKING UNIT

Kind of Timber	Tension	
	With Grain	Across Grain
White Oak	12000	2000
White Pine	7000	500
Southern Long-leaf or Georgia Yellow Pine	12000	600
Douglas Fir	8000	....
Short-leaf Yellow Pine	9000	500
Red Pine (Norway Pine)	8000	500
Spruce and Eastern Fir	8000	500
Hemlock	6000	....
Cypress	6000	....
Cedar	7000	....
Chestnut	8500	....
California Redwood	7000	....
California Spruce	....	....

AVERAGE SAFE ALLOWABLE WORKING UNIT

Kind of Timber	Tension	
	With Grain	Across Grain
Factor of Safety	Ten	Ten
White Oak	1200	200
White Pine	700	50
Southern Long-leaf or Georgia Yellow Pine	1200	60
Douglas Fir	800	....
Short-leaf Yellow Pine	900	50
Red Pine (Norway Pine)	800.	50
Spruce and Eastern Fir	800	50
Hemlock	600	....
Cypress	600	....
Cedar	700	....
Chestnut	850	....
California Redwood	700	....
California Spruce	....	....

The above tables are based on those recommended by the committee on intendents of Bridges and Buildings at their Fifth Annual Convention, in October, data from various sources.

STRESSES, IN POUNDS PER SQUARE INCH

COMPRESSION			TRANSVERSE		SHEARING	
With Grain		Across Grain	Extreme Fibre Stress	Modulus of Elasticity	With Grain	Across Grain
End Bearing	Columns Under 15 Diams.					
7000	5000	2000	7000	1500000	800	4000
5500	3500	700	4000	1000000	400	2000
7000	5000	1400	7000	1500000	600	5000
5700	4500	800	5000	1400000	500	....
6000	4500	1000	6000	1200000	400	4000
5000	4000	800	5000	1130000	....	....
6000	4000	700	4000	1200000	400	3000
....	4000	600	3500	900000	350	2500
5000	4000	700	5000	900000	....	....
5500	3500	700	4000	700000	400	1500
....	4000	900	5000	1000000	600	2000
....	4000	600	4500	700000	400	....
....	4000	....	5000	1200000	....	....

STRESSES, IN POUNDS PER SQUARE INCH

COMPRESSION			TRANSVERSE		SHEARING	
With Grain		Across Grain	Extreme Fibre Stress	Modulus of Elasticity	With Grain	Across Grain
End Bearing	Columns Under 15 Diams.					
Five	Five	Four	Six	Two	Four	Four
1400	1000	500	1200	750000	200	1000
1100	700	200	700	500000	100	500
1400	1000	350	1200	750000	150	1250
1100	900	200	800	750000	130	....
1200	900	250	1000	600000	100	1000
1000	800	200	800	565000	....	....
1200	800	200	700	600000	100	750
....	800	150	600	450000	100	600
1000	800	200	800	450000	....	....
1100	700	200	700	350000	100	400
....	800	250	800	500000	150	500
....	800	150	750	350000	100	....
....	800	....	800	600000	....	....

"Strength of Bridge and Trestle Timbers" of the Association of Railway Super-
1895, but the arrangement and values in many cases are now modified by later

SAFE LOADS IN POUNDS UNIFORMLY DISTRIBUTED FOR CEDAR AND SPRUCE

Allowable fibre stress 700 pounds per square inch. Safety

Safe loads for other safety factors may be obtained as follows:

Span in Feet	DEPTH OF BEAM IN INCHES											Deflection Coefficient for White Pine
	4	5	6	7	8	9	10	11	12	13	14	V
4	311	486	700	953	1244	1575	1944	2352	2800	3286	3811	.34
5	240	389	560	762	996	1260	1556	1882	2240	2629	3049	.53
6	207	324	467	635	830	1050	1296	1569	1867	2191	2521	.76
7	178	278	400	544	711	900	1111	1344	1600	1878	2178	1.03
8	156	243	350	476	622	788	972	1176	1400	1643	1906	1.34
9	138	216	311	423	553	700	864	1046	1244	1460	1694	1.70
10	124	194	280	381	498	630	778	941	1120	1314	1524	2.10
11	113	177	155	346	453	573	707	856	1018	1195	1386	2.54
12	103	162	233	318	415	525	648	784	933	1095	1270	3.02
13	96	150	215	293	383	485	598	724	862	1011	1173	3.55
14	89	139	200	272	356	450	556	672	800	930	1089	4.12
15	83	130	187	254	332	420	519	627	747	876	1016	4.73
16	78	122	175	238	311	394	486	588	700	821	953	5.38
17	73	114	165	224	293	371	458	554	659	773	897	6.07
18	69	108	156	212	277	350	432	523	622	730	847	6.80
19	65	102	147	201	262	332	409	495	589	692	802	7.58
20		97	140	191	249	315	389	471	560	657	762	8.40
21		93	133	182	237	300	370	448	533	626	726	9.26
22		88	127	173	226	286	354	428	509	597	693	10.16
23		85	122	166	216	274	338	409	487	572	663	11.11
24			117	159	207	263	324	392	467	548	635	12.10
25			112	152	199	252	311	376	448	526	610	13.13
26			108	147	191	242	299	362	431	506	586	14.20
27			104	141	184	233	288	349	415	487	565	15.31
28			100	136	178	225	278	336	400	469	544	16.46
29			97	131	172	217	268	325	386	453	526	17.66
30			93	127	166	210	259	314	373	438	508	18.90
31			90	123	161	203	251	304	361	424	492	20.18
32			88	119	156	197	243	294	350	411	476	21.50
33			85	115	151	191	236	285	339	398	462	22.87
34				112	146	185	229	277	329	387	448	24.28
35				109	142	180	222	269	320	376	436	25.73

RECTANGULAR BEAMS ONE INCH THICK OF WHITE PINE, OR EASTERN FIR

factor 6. Modulus of rupture 4200 pounds per square inch.

$$\text{New safe load} = \text{Safe load from table} \times \frac{6}{\text{New factor}}.$$

Span in Feet	DEPTH OF BEAM IN INCHES										Deflection Coefficient for White Pine V
	15	16	17	18	19	20	21	22	23	24	
9	1944	2212	2498	2800	3120	3457	3811	4183	4571	4978	1.70
10	1750	1991	2248	2520	2808	3111	3430	3764	4114	4480	2.10
11	1601	1810	2044	2291	2552	2828	3118	3422	3740	4073	2.54
12	1458	1659	1873	2100	2340	2593	2858	3137	3428	3733	3.02
13	1346	1531	1729	1938	2160	2393	2638	2896	3165	3446	3.55
14	1250	1422	1606	1800	2056	2222	2450	2689	2939	3200	4.12
15	1167	1328	1499	1680	1872	2074	2287	2510	2743	2987	4.73
16	1094	1244	1405	1575	1755	1944	2144	2353	2571	2800	5.38
17	1029	1171	1322	1482	1652	1830	2018	2214	2420	2635	6.07
18	972	1106	1249	1400	1560	1728	1906	2091	2286	2489	6.80
19	921	1048	1183	1326	1478	1637	1805	1981	2165	2358	7.58
20	875	996	1124	1260	1404	1556	1715	1882	2057	2240	8.40
21	833	948	1070	1200	1337	1481	1633	1793	1959	2133	9.26
22	795	905	1022	1145	1276	1414	1559	1711	1870	2036	10.16
23	761	866	977	1096	1221	1353	1491	1637	1789	1948	11.11
24	729	830	937	1050	1170	1296	1429	1569	1714	1867	12.10
25	700	796	899	1008	1123	1244	1372	1506	1645	1792	13.13
26	673	766	865	969	1080	1197	1319	1448	1582	1723	14.20
27	648	737	833	933	1040	1152	1270	1394	1524	1659	15.31
28	625	711	803	900	1003	1111	1225	1344	1469	1600	16.46
29	603	687	775	869	968	1073	1183	1298	1419	1545	17.66
30	583	664	749	840	936	1037	1143	1255	1371	1493	18.90
31	565	642	725	813	906	1004	1106	1214	1327	1445	20.18
32	547	622	703	787	877	972	1072	1176	1286	1400	21.50
33	534	603	681	764	850	943	1039	1141	1247	1358	22.87
34	515	586	661	741	826	915	1009	1107	1210	1318	24.28
35	500	569	642	720	802	880	980	1076	1176	1280	25.73
36	486	553	624	700	780	864	953	1046	1143	1244	27.22
37	473	538	608	681	759	841	927	1017	1112	1211	28.75
38	460	524	592	663	739	819	903	991	1083	1179	30.32
39	449	511	576	646	720	798	880	965	1055	1149	31.94
40	438	498	562	630	702	778	858	941	1029	1120	33.60

SAFE LOADS IN POUNDS UNIFORMLY DISTRIBUTED, SHORT-LEAF

Allowable fibre stress 1000 pounds per square inch. Safety

Safe loads for other safety factors may be obtained as follows:

Span in Feet	Depth of Beam in Inches											Deflection Coefficient
	4	5	6	7	8	9	10	11	12	13	14	V
4	444	694	1000	1361	1778	2250	2778	3361	4000	4694	5444	.40
5	356	556	800	1089	1422	1800	2222	2689	3200	3756	4356	.63
6	296	463	667	907	1185	1500	1852	2241	2667	3130	3630	.90
7	254	397	571	778	1016	1286	1587	1921	2286	2683	3111	1.23
8	222	347	500	681	889	1125	1389	1681	2000	2347	2722	1.60
9	198	309	444	605	790	1000	1235	1494	1778	2086	2420	2.03
10	178	278	400	544	711	900	1111	1344	1600	1878	2178	2.50
11	162	253	364	495	646	818	1010	1222	1455	1707	1980	3.03
12	148	231	333	454	593	750	926	1120	1333	1565	1815	3.60
13	137	214	308	419	547	692	855	1034	1231	1444	1675	4.23
14	127	198	286	389	508	643	794	960	1143	1341	1556	4.90
15	119	185	267	363	474	600	741	896	1067	1252	1452	5.63
16	111	174	250	340	444	563	604	840	1000	1174	1361	6.40
17	105	163	235	320	418	529	654	791	941	1105	1281	7.23
18	99	154	222	302	395	500	617	747	889	1043	1210	8.10
19	94	146	211	287	374	474	585	708	842	988	1146	9.03
20	89	139	200	272	356	450	556	672	800	939	1089	10.00
21	85	132	190	259	339	429	529	640	762	894	1037	11.03
22	81	126	182	247	323	409	505	611	727	854	990	12.10
23	77	121	174	237	309	391	483	585	696	816	947	13.23
24		116	162	227	296	375	463	560	667	782	907	14.40
25		111	160	218	284	360	444	538	640	751	871	15.63
26		107	154	209	274	346	427	517	615	722	838	16.90
27		103	148	202	263	333	412	498	593	695	807	18.23
28		99	143	194	254	321	397	480	571	671	778	19.60
29			138	188	245	310	383	464	552	648	751	21.03
30			133	181	237	300	370	448	533	626	726	22.30
31			129	176	229	290	358	434	516	606	703	24.03
32			125	170	222	281	347	420	500	587	681	25.60
33			121	165	215	273	337	407	485	569	660	27.23
34			118	160	209	265	327	395	471	552	641	29.90
35			114	156	203	257	317	384	457	537	602	30.63

Safe loads for any fibre stress may be readily obtained from this table by proportion.

FOR RECTANGULAR BEAMS ONE INCH THICK, OF YELLOW PINE

factor 6. Modulus of rupture 6000 pounds per square inch.

$$\text{New safe load} = \text{Safe load from table} \times \frac{6}{\text{New factor}}.$$

Span in Feet	DEPTH OF BEAM IN INCHES										Deflection Coefficient
	15	16	17	18	19	20	21	22	23	24	V
9	2778	3160	3568	4000	4457	4038	5444	5975	6531	7111	2.03
10	2500	2844	3211	3600	4011	4444	4900	5378	5878	6400	2.50
11	2273	2586	2919	3273	3646	4040	4455	4889	5343	5818	3.03
12	2083	2370	2676	3000	3343	3704	4083	4481	4898	5333	3.60
13	1923	2188	2470	2760	3085	3419	3769	4137	4521	4923	4.23
14	1786	2032	2294	2571	2865	3175	3500	3841	4198	4571	4.00
15	1667	1896	2141	2400	2674	2963	3267	3585	3919	4267	5.63
16	1563	1778	2007	2250	2507	2778	3062	3361	3674	4000	6.40
17	1471	1673	1889	2118	2359	2614	2882	3463	3458	3765	7.23
18	1389	1580	1789	2000	2228	2469	2722	2988	3265	3556	8.10
19	1316	1497	1690	1895	2111	2339	2570	2830	3004	3368	9.03
20	1250	1422	1606	1800	2006	2222	2450	2689	2939	3200	10.00
21	1190	1354	1529	1714	1910	2116	2333	2561	2799	3048	11.03
22	1136	1293	1460	1636	1823	2020	2227	2444	2672	2909	12.10
23	1087	1237	1396	1565	1744	1932	2130	2338	2556	2783	13.23
24	1042	1185	1338	1500	1671	1852	2042	2241	2449	2667	14.40
25	1000	1138	1284	1440	1604	1778	1960	2131	2351	2560	15.63
26	962	1094	1235	1385	1543	1700	1885	2068	2261	2462	16.00
27	926	1053	1189	1333	1486	1646	1815	1992	2177	2370	18.23
28	893	1016	1147	1286	1433	1587	1750	1921	2099	2286	19.60
29	862	981	1107	1241	1383	1533	1690	1854	2027	2207	21.03
30	833	948	1070	1200	1337	1481	1633	1793	1959	2133	22.50
31	806	918	1036	1161	1294	1434	1581	1735	1896	2065	24.03
32	781	889	1003	1125	1253	1389	1531	1681	1837	2000	25.60
33	758	862	973	1091	1215	1347	1485	1630	1781	1939	27.23
34	735	837	944	1059	1180	1307	1441	1582	1728	1882	28.90
35	714	813	917	1029	1146	1270	1400	1537	1677	1829	30.63
36	694	780	894	1000	1114	1235	1361	1494	1633	1778	32.40
37	676	769	868	973	1084	1201	1324	1453	1589	1730	34.23
38	658	749	845	947	1056	1169	1289	1415	1547	1684	36.10
39	641	729	823	923	1028	1140	1256	1379	1507	1641	38.03
40	625	711	803	900	1003	1111	1225	1344	1469	1600	40.00

Safe loads for beams of California Redwood, three-quarters of above.

SAFE LOADS IN POUNDS UNIFORMLY DISTRIBUTED, WHITE OAK AND

Allowable fibre stress 700 pounds per square inch. Safety

Safe loads for other safety factors may be obtained as follows:

Span in Feet	Depth of Beam in Inches											Deflection Coefficient
	4	5	6	7	8	9	10	11	12	13	14	V
4	533	833	1200	1633	2133	2700	3333	4033	4800	5633	6533	.38
5	427	667	960	1307	1707	2160	2667	3227	3840	4507	5227	.60
6	356	556	800	1089	1422	1800	2222	2689	3200	3756	4356	.86
7	305	476	686	933	1219	1543	1905	2305	2743	3219	3733	1.18
8	267	417	600	817	1067	1350	1667	2017	2400	2817	3267	1.54
9	237	370	533	726	948	1200	1481	1793	2133	2504	2904	1.94
10	213	333	480	653	853	1080	1333	1613	1920	2253	2613	2.40
11	194	303	436	594	776	982	1212	1467	1745	2048	2376	2.90
12	178	278	400	544	711	900	1111	1344	1600	1878	2178	3.46
13	164	256	369	503	656	831	1026	1241	1477	1733	2010	4.06
14	152	238	343	467	610	771	952	1152	1371	1610	1867	4.70
15	142	222	320	436	569	720	889	1076	1280	1502	1742	5.40
16	133	298	300	408	533	675	833	1008	1200	1408	1633	6.14
17	125	196	282	384	502	635	784	949	1129	1325	1537	6.94
18	119	185	267	363	474	600	741	896	1067	1252	1452	7.78
19	112	175	253	344	449	568	702	849	1011	1186	1375	8.66
20	107	167	240	327	427	540	667	807	960	1127	1307	9.60
21	102	159	229	311	406	514	635	768	914	1073	1244	10.58
22	97	152	218	297	388	401	606	733	873	1024	1188	11.62
23	93	145	209	284	371	470	580	701	835	980	1136	12.70
24	89	139	200	272	356	450	556	672	800	939	1089	13.82
25	85	133	192	261	341	432	533	645	768	901	1045	15.00
26		128	185	251	328	415	513	621	738	867	1005	16.22
27		123	178	242	316	400	404	598	711	835	968	17.50
28		119	171	233	305	386	476	576	685	805	933	18.82
29		115	166	225	294	372	460	556	662	777	901	20.18
30		111	160	218	284	360	444	538	640	751	871	21.60
31		108	155	211	275	348	430	520	619	727	843	23.06
32			150	204	267	338	417	504	600	704	817	24.58
33			145	198	259	327	404	489	582	683	792	26.14
34			141	192	251	318	392	475	565	663	769	27.74
35			137	187	244	309	381	461	549	644	747	29.40

Safe loads for beams of Douglas Fir, Red Pine (Norway Pine), Cypress, Chestnut and California Spruce, two-thirds of above.

FOR RECTANGULAR BEAMS ONE INCH THICK, OF LONG-LEAF YELLOW PINE

factor 6. Modulus of rupture 7200 pounds per square inch.

New safe load = Safe load from table × $\frac{6}{\text{New factor}}$.

Span in Feet	Depth of Beam in Inches										Deflection Coefficient
	15	16	17	18	19	20	21	22	23	24	V
9	3333	3793	4281	4800	5348	5926	6533	7170	7837	8533	1.94
10	3000	3413	3853	4320	4813	5333	5880	6453	7053	7680	2.40
11	2727	3103	3503	3927	4376	4848	5355	5867	6412	6892	2.90
12	2500	2844	3211	3600	4011	4444	4900	5378	5878	6400	3.46
13	2308	2626	2964	3323	3703	4103	4523	4964	5426	5908	4.06
14	2143	2438	2752	3086	3438	3810	4200	4610	5038	5486	4.70
15	2000	2276	2569	2880	3209	3556	3920	4302	4702	5120	5.40
16	1875	2133	2408	2700	3008	3333	3675	4033	4433	4800	6.14
17	1765	2008	2267	2541	2831	3137	3459	3796	4149	4518	6.94
18	1667	1896	2141	2400	2674	2963	3267	3585	3819	4267	7.78
19	1579	1796	2027	2274	2533	2807	3095	3396	3712	4042	8.66
20	1500	1707	1927	2160	2407	2667	2940	3227	3527	3840	9.60
21	1429	1625	1835	2057	2292	2540	2800	3073	3359	3657	10.58
22	1364	1552	1752	1964	2188	2424	2678	2933	3206	3491	11.62
23	1304	1484	1675	1878	2093	2319	2557	2806	3067	3339	12.70
24	1250	1422	1606	1800	2006	2222	2450	2689	2939	3200	13.82
25	1200	1365	1541	1728	1925	2133	2352	2581	2821	3072	15.00
26	1154	1313	1482	1662	1851	2051	2262	2482	2713	2954	16.22
27	1111	1264	1427	1600	1783	1975	2178	2390	2612	2844	17.50
28	1071	1219	1376	1543	1719	1905	2100	2305	2519	2743	18.82
29	1034	1177	1329	1490	1660	1839	2028	2225	2432	2648	20.18
30	1000	1138	1284	1440	1604	1778	1960	2151	2351	2560	21.60
31	968	1101	1243	1394	1553	1720	1897	2082	2275	2477	23.06
32	938	1067	1204	1350	1504	1667	1838	2017	2217	2400	24.58
33	909	1034	1168	1309	1459	1616	1785	1956	2137	2327	26.14
34	822	1004	1133	1271	1416	1569	1729	1898	2075	2259	27.74
35	857	975	1101	1234	1375	1524	1680	1844	2013	2194	29.40
36	833	948	1070	1200	1337	1481	1633	1793	1909	2133	31.10
37	811	923	1041	1168	1301	1441	1589	1744	1906	2076	32.85
38	789	893	1014	1137	1267	1404	1547	1698	1856	2021	34.66
39	769	875	988	1108	1234	1368	1508	1655	1809	1969	36.50
40	750	853	963	1080	1203	1333	1470	1613	1763	1920	38.40

Safe loads for beams of Hemlock, one-half of above.

STRENGTH OF SOLID WOODEN COLUMNS OF DIFFERENT KINDS OF TIMBER

For various values of $\frac{l}{d}$.

l = length of column in inches. d = least diameter in inches.

Based on the Formula of the U. S. Department of Agriculture, Division of Forestry.

$$P = F \times \frac{700 + 15c}{700 + 15c + c^2}.$$

P = ultimate strength in pounds per square inch.

F = ultimate crushing strength of timber. $c = \frac{l}{d}$.

Values of F are those given in table on pages 448 and 449 herein.

	ULTIMATE STRENGTH IN POUNDS PER SQUARE INCH			
	White Oak and Southern Long-leaf or Georgia Yellow Pine	Douglas Fir and Short-leaf Yellow Pine	Red Pine (Norway Pine), Spruce or Eastern Fir, Hemlock, Cypress, Chestnut, California Redwood and California Spruce	White Pine and Cedar
F	5000	4500	4000	3500
$\frac{l}{d}$				
2	4937	4475	3978	3481
3	4940	4446	3952	3458
4	4897	4407	3918	3428
5	4844	4359	3875	3391
6	4782	4304	3826	3347
7	4713	4242	3770	3299
8	4638	4174	3710	3247
9	4558	4102	3646	3190
10	4474	4026	3579	3132
11	4386	3948	3509	3070
12	4297	3867	3438	3008
13	4206	3785	3365	2944
14	4114	3703	3291	2880
15	4022	3620	3217	2815
16	3930	3537	3144	2751
17	3838	3455	3071	2687
18	3748	3373	2998	2624
19	3659	3293	2927	2561

For safety factors for various classes of structures to be used in connection with the above table, see p. 446.

STRENGTH OF SOLID WOODEN COLUMNS OF DIFFERENT KINDS OF TIMBER

For various values of $\frac{l}{d}$.

l = length of column in inches. d = least diameter in inches.

Based on the Formula of the U. S. Department of Agriculture, Division of Forestry.

$$P = F \times \frac{700 + 15c}{700 + 15c + c^2}.$$

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	Ultimate Strength in Pounds per Square Inch			
	White Oak and Southern Long-leaf or Georgia Yellow Pine	Douglas Fir and Short-leaf Yellow Pine	Red Pine (Norway Pine), Spruce or Eastern Fir, Hemlock, Cypress, Chestnut, California Redwood and California Spruce	White Pine and Cedar
F	5000	4500	4000	3500
$\frac{l}{d}$				
20	3571	3214	2857	2500
21	3486	3137	2788	2440
22	3402	3061	2721	2381
23	3320	2988	2656	2324
24	3240	2916	2592	2268
25	3162	2846	2529	2213
26	3086	2777	2469	2160
27	3013	2711	2410	2109
28	2941	2647	2353	2059
29	2872	2585	2298	2010
30	2805	2524	2244	1963
32	2677	2409	2142	1874
34	2557	2301	2046	1790
36	2445	2200	1956	1711
38	2340	2106	1872	1638
40	2241	2017	1793	1569
42	2149	1934	1719	1505
44	2063	1857	1650	1444
46	1982	1784	1586	1388
48	1907	1716	1525	1335
50	1835	1652	1468	1285

For safety factors for various classes of structures to be used in connection with the above table, see p. 446.

SPECIFICATIONS FOR VAULTS*

CLASS A VAULTS

Vaults designed to afford the maximum degree of protection and intended for the use of banks, trust companies, and others having large values to protect. This type of vault involves massive construction, designed to resist long continued fire, impact of falling objects, and attack by burglars (in so far as this feature can properly be incorporated in these specifications).

MATERIAL.—1. Reinforced Concrete. Walls, roofs, and floors shall be of reinforced concrete, and mixture not poorer than one part of Portland cement to six parts of aggregate, so proportioned as to give maximum density.

Coarse aggregate shall consist of trap rock, broken, hard burned or vitreous bricks, or their equivalent, and pass over a ¼-inch screen and through a 1-inch ring. Stones which calcine or spall readily shall be avoided.

While not recommended, it is possible that under certain conditions the use of a first class quality of hard burned brick laid in cement mortar may be advisable for walls, or a combination of an exterior brick shell and an interior concrete wall may be used.

2. Reinforcing Material. Reinforcement for concrete shall consist of steel rods at least ½ inch in diameter, spaced 4 inches on centres, and running in both directions at right angles to each other. These rods shall be securely wired together at intersections not over 12 inches apart in both directions, and shall be installed with one set placed 3 inches from each face of each wall.

Any other form of reinforcing, of equal or greater cross section, may be used.

Rolled beams or rails are frequently used for roof and floor reinforcement and are occasionally used in walls as well, both to secure fire and burglar resisting powers. They are advised in the case of roofs, because of their impact resisting powers.

3. Continuous construction. Concrete work should be carried on continuously as nearly as practicable and be thoroughly tamped and spaded. Walls should be carried up uniformly.

WALLS.—4. Support. Shall be built on ground (on rock if possible) in non-fireproof buildings, and preferably also in fireproof ones.

Where supported on steel framework of a building, supporting steel shall have especially large factor of safety, shall be protected with at least 6 inches of reinforced concrete, and reinforcing material around columns and beams shall be securely anchored.

NOTE.—Concrete is specified for protection to steel, because both materials have approximately the same co-efficient of expansion.

5. Independent. Walls of vaults shall be entirely independent of those of building, and at a sufficient distance to permit of inspection.

6. Carrying Floors. Floors of building shall preferably be independent of vault walls, but, if connected, shall be so arranged that in event of building collapsing they will pull away without reducing the strength or fire-resisting qualities of the vaults.

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*As given in the regulations of the National Board of Fire Underwriters.

7. Thickness. Reinforced concrete wall shall be at least 16 inches thick. Brick walls shall be at least 20 inches thick. If concrete wall is protected with a brick shell, concrete shall be at least 12 inches, and brick at least 8 inches thick.

ROOF.—8. Thickness. Shall be at least 4 inches greater than for walls, and, in buildings where great impact possibilities exist, frequently much thicker.

9. Strength. Shall have strength of spans consistent with surrounding conditions, especially possible impact of falling bodies, such as walls, safes, and machinery.

10. Interior Columns. Where span is sufficiently large, the introductions of interior columns or girders or division walls may be necessary. Steel columns or girders shall be protected with at least 2 inches of reinforced concrete.

FLOORS.—11. Thickness. Shall be at least 12 inches thick where laid upon ground, or on beams to permit inspection, and thicker if deemed necessary.

NOTE.—To permit of inspection to protect against tunneling into vaults, floors are sometimes placed on parallel beams.

Where vault is over one story high, and where each story is entered separately, the floors between stories shall be at least 6 inches thick and not pierced.

12. Flooring. No combustible surface flooring shall be used. This is not intended to prohibit the limited use of non-flammable runners.

ENTRANCE ENCLOSURES.—13. Entrance enclosures are recommended to protect doors of very important vaults against fire and against attack by mobs.

DOORS.—14. Single doors (without inner doors, creating dead air spaces) shall be at least 16 inches thick, and shall contain at least 6 inches of concrete filling of as large an area as the design will permit.

15. When double doors are used, outer doors shall be at least 8 inches thick, and shall contain at least 3 inches of concrete filling, and of as large an area as the design will permit.

16. Emergency doors, if provided, shall be equal in strength and thickness to main door, and an interference device shall be provided to prevent the main door being closed until the emergency one is closed and locked.

17. Fit. Outer door shall be stepped or tongued and grooved, or both, in order to protect against fire, smoke, and water.

Important doors should have doors and jambs ground to a fit, should be provided with packing, and such doors and jambs should be tested for waterproofness after erection.

It is suggested that packing may advantageously be provided on inner doors as additional protection.

18. When double doors are used, inner doors shall be of steel plate, at least ½ inch thick, reinforced to give stability, and provided with suitable locking mechanism.

19. The air space between inner and outer doors shall be at least 12 inches.

INTERFERENCE MECHANISM.—20. Shall preferably be provided so as to make it necessary to close inner doors before outer ones, when double doors are used.

WATER-TIGHTNESS.—21. Walls, roof, and floors to be effectively waterproofed, but no combustible material shall be used for this purpose.

Where vaults are located in basements or at other low points, special provision to prevent entrance of water, such as raised sills, large area floor drains for basement, and packing in grooves may be warranted.

Storage vaults often can have raised sills without inconvenience. Operating vaults, where travel through openings, including that by trucks, is frequent, can usually not have a sill more than a few inches high, even where provided with a sloping approach.

Where there is a possibility of water entering vaults, contents that can be damaged by water should not be placed close to the floor.

VENTILATION.—22. Ventilation of interior shall be only through doors. Walls, floors, and roofs shall not be pierced. For large vaults, inside permanent duct systems, fed by temporary section of ducts when doors are open, are used.

INTERIOR EQUIPMENT.—23. Shelving, stairs, book lifts, and all other interior equipment shall be entirely of metal. Designs embodying compartments with doors shall be used for the storage of papers or other combustible materials.

LIGHTING.—24. a. Shall be by electricity only, and wiring shall be installed in accordance with the National Electrical Code.

b. Where possible it is recommended that current be secured through a cord carried from an inside connection to an outside one and after the opening of the door.

c. If wiring enters the vault except through the door opening, it shall enter the vault wall near the floor, be encased near the outer surface of the wall to a point near the ceiling of the vault, and then enter the vault.

d. The closing of the door shall automatically cut off current except that some emergency lighting may remain in service, and that provision may be made for telephone, annunciator, and alarm connections.

e. Pendant cords shall be avoided. If used, they shall be of reinforced type, and lamps shall have guards.

CLASS B VAULTS

NOTE.—Vaults usually erected in tiers and designed to afford a large measure of protection to their contents, assuming even the total burn-out of the building in which the vault is located.

AREA.—1. Inside floor area shall not exceed 150 square feet. Height will naturally be similar to that of stories where a tier of vaults is built.

MATERIAL.—2. Concrete or Brick. Reinforced concrete of same quality specified for Class "A" Vaults, or hard burned brick laid in Portland cement mortar shall be used.

3. Reinforcement. If reinforced concrete is used, the reinforcing material shall consist of steel rods at least ½ inch in diameter, spaced 4 inches on centres and running in both directions at right angles to each other. These rods shall be securely wired together at intersections not over 12 inches apart in both directions, and be installed in centre of wall.

Any other form of reinforcing, of equal or greater cross section, may be used.

Rolled beams or rails are frequently used for floor and roof reinforcement and are occasionally used in walls as well, both to secure fire and burglar resisting powers. They are advised in the case of roofs because of their impact resisting powers.

4. Continuous Construction. The principles laid down for Class "A" Vaults shall be followed where reinforced concrete is used.

WALLS.—5. Support. Shall preferably be built on the ground, on rock if possible, and shall have footings capable of carrying the load without danger of settling.

Where walls do not rest upon the ground, they shall rest upon steel framework, which is insulated against heat with concrete in the same manner specified for Class "A" Vaults.

6. Independent. Shall preferably be independent of the walls of the building, but, if not, shall be effectively bonded to the building walls.

7. Thickness. Concrete walls shall be not less than 12 inches thick for 3 upper stories, and not less than 16 inches thick for next 3 stories below. Brick walls shall be not less than 16 inches thick for 3 upper stories, and not less than 20 inches thick for next 3 stories below.

8. Carrying of Floors. Building floors shall preferably not be carried by vault walls, but if so carried the wall thickness at no point to be less than 12 inches in the case of concrete and not less than 16 inches in that of brick, and floor beams shall be self-releasing.

ROOF.—9. Thickness. When of reinforced concrete shall be not less than 12 inches thick, and, where top of vault is below roof of building, thickness may need to be increased to provide strength to resist impact.

Brick arch roofs, while not objectionable, are not recommended. If used, minimum thickness of arch shall be 16 inches. Tie rods may be needed.

10. Strength. Shall have strength of spans consistent with surrounding conditions, especially possible impact of falling bodies, such as walls, safes and machinery.

FLOORS.—11. Thickness. Shall be not less than 8 inches thick if of reinforced concrete and not less than 12 inches thick if brick arched.

12. Flooring. No combustible flooring shall be used.

DOORS.—These specifications closely follow the National Board of Fire Underwriters' Regulations for the Construction and Installation of Fire Doors and Shutters; see page 367.

INNER DOORS.—19. a. Plates to be not less than ⅛ inch iron or steel. Plates to be reinforced around all edges with 1½ x ¼ inch bar iron, or equivalent, secured with rivets at least ¼ inch in diameter and spaced not over 9 inches on centres.

b. Doors to be provided with at least two hinges each, material to be not less than 1½ x ¼ inch, secured with at least two rivets to both frame and door.

c. Latches to engage at top and bottom, and at least at one point on meeting edges of doors. Doors to fit frames tightly.

AIR SPACE.—20. Between inner and outer doors there shall be at least 12 inches of air space.

INTERFERING MECHANISM, WATER-TIGHTNESS, VENTILATION, INTERIOR EQUIPMENT and LIGHTING.—Same as for Class "A" Vaults.

CLASS C VAULTS

Vaults erected upon the framework of fireproof buildings; the safety of such vaults is directly dependent upon the fireproof qualities of the buildings. Vaults built in vertical lines make it possible to provide particularly good fireproofing for bays in which such vaults are located.

SIZE.—1. Inside floor area shall not exceed 100 square feet.

Clearance between top of vault and lowest structural member of floor above shall not be less than 12 inches, and space between top of vault and floor above shall be closed up with non-combustible material which will readily crush in event of deflections of floors.

MATERIAL.—2. Shall be of reinforced concrete of the same quality as specified for Class "A" Vaults.

Reinforcement for concrete shall consist of steel rods at least ½ inch in diameter, spaced 4 inches on centres and running in both directions at right angles to each other. These rods shall be securely wired together at intersections not over 12 inches apart in both directions, and be installed centrally in each wall.

Any other form of reinforcement, of equal or greater cross section, may be used.

WALLS.—3. Thickness. Shall be at least 8 inches thick.

Supports. Shall be, in so far as possible, built upon the girders and beams of the building. Special framework, to take care of the vault loads, is often advisable. Special care shall be exercised in fireproofing these supporting members. Columns shall not pass through vaults or their walls.

4. Independent. Shall be independent of walls of buildings, of partitions, and of fireproofing of columns. Each vault preferably shall be independent of other vaults.

FLOORS.—5. Floors of vaults may serve as floors of buildings provided the reinforcing material is protected with at least 2 inches of concrete.

6. Thickness. Shall be at least 8 inches thick.

7. Flooring. No combustible flooring shall be permitted.

ROOFS.—8. Reinforcement. Same as for floors.

9. Thickness. Shall be at least 8 inches thick, and the top of any vault one or more stories below the roof of the building in which it is located shall be at least 12 inches thick, providing there is no other vault immediately above it.

10. Independent. Roofs of vaults shall be independent of floors, roofs, or ceilings of buildings.

DOORS.—11. Single doors, not less than 8 inches thick, and containing not less than 3 inches of concrete, are considered desirable for this class of vault. By means of packing and a pressure mechanism considerable water-tightness can be secured. Otherwise the double type of door shall be used, as per the Class "B" Vault specification.

INTERFERING MECHANISM, WATER-TIGHTNESS, VENTILATION, INTERIOR EQUIPMENT and LIGHTING.—Same as for Class "A" Vaults.

PROTECTION

FIRE PROTECTION FOR PEOPLE IN BUILDINGS

In his testimony before the State Factory Investigating Commission in 1912, Mr. Rudolph P. Miller, Superintendent of the Bureau of Buildings for the Borough of Manhattan, recommended the adoption of radical measures, substantially as follows, for the protection against fire of factory workers and others:

Systematic inspection to see that safe conditions are maintained should be provided. Ample authority should be given to the administrative officer to secure compliance with the provisions of law. The necessary exit facilities and physical safeguards should be prescribed in sufficient detail to fix a safe standard. The number of occupants should be limited by law in accordance with the exit facilities provided.

The occupancy of a new building or the change of occupancy of an existing building should be prohibited until a certificate has been issued by the proper authority. Fire drills, or at least adequate instructions to employees as to safeguarding life, should be demanded in all workshops and factories. The jurisdiction over exit facilities and inspection in connection therewith should be vested with the same officials that administer the building law.

Stairs.—No door, stair or passageway shall be less than 3 ft. 4 in. in the clear. At least two separate staircases, with the necessary doors and passageways, shall be provided for any building over three stories in height or over 3,000 sq. ft. in area. When more than one is required the stairs shall be so placed that at least one is always accessible to the occupants in case any one of the others is rendered impassable for some reason, and that it shall not be necessary to travel more than 80 ft. in a direct horizontal line to reach either one of any two. All stairs shall be enclosed in an approved fireproof construction and shall have a direct exterior outlet to the street or to a court leading to a street, at the ground floor. The risers and treads of stairs shall be so proportioned that the stairs furnish a safe and comfortable line of travel. . . . No flight of stairs shall have a vertical rise of more than 12 ft. between floors or intermediate platforms; and in straight runs platforms shall be spaced equidistant between upper and lower limits.

Doors and Passageways.—The aggregate clear width of doors and passageways intended to serve as exits from any building or part of a building shall be at least 12 in. for every twenty persons to be accommodated, provided none is less than 40 in. wide.

The aggregate clear width of stairs and stair halls shall be such that the stairs in any story of a building may accommodate at one time the total number of persons ordinarily occupying or permitted to occupy any one floor above the flight of stairs under consideration, on the basis that at least 20 in. of width and one and one-half treads are required per person.

When the building is of thoroughly fire-proof construction, with no communication from floor to floor except by elevators in solid fireproof enclosures and stairs in fire towers constructed as herein elsewhere described and all openings to the outer air are protected by metal and wire glass windows or doors of approved construction, a reduction of 20 per cent. in the aggregate width may be made.

When an approved equipment of automatic sprinklers is installed in any building, a reduction of 25 per cent. in the aggregate width specified may be made.

When fire walls, of such strength and construction as to resist fire for at least 30 minutes, equipped with adequate openings protected by approved automatic fire doors, are provided, a reduction of 33⅓ per cent. in the aggregate width specified may be made.—From the Engineering Record, Sept. 14, 1912.

Improvement to Existing Fire Escapes.—Considerable attention has been given to the improvement of fire escape facilities in the Borough of Manhattan, New York, by the Bureau of Buildings. Although exterior fire escapes are considered as more or less unsatisfactory makeshifts on account of their exposure to flame and smoke and for other reasons, some valuable improvements have recently been made in them.

In New York ordinary outside fire escapes generally consist of a series of iron balconies at the several stories, connected by stairs and provided with a movable ladder to be let down from the lowest balcony if necessary. It was found that these ladders, although limited in length and strength, were often too heavy to be safely handled by the people forced to use the fire escape, and that firemen were frequently required to assist people down the fire escapes. It is, therefore, recommended that the lowest ladder shall be balanced with a counterweight and furnished with guides to insure its control.

In cases where a large number of people are to be cared for balanced iron stairs are recommended to give a higher capacity than is possible with ladders. As the use of balancing ladders or stairs permits them to be longer the height of the lowest balcony above the street may be increased and recourse may be had to intermediate platforms, as shown in the view of balanced first-escape stairs.

For factories, schools and other buildings where there are apt to be large numbers of people, exterior stairways with steel supports have been required. The capacities of some ordinary outside fire escapes have been greatly increased by arranging two intersecting stairs in the form of an X in the spaces between successive balconies usually occupied by a single stair.—From The Engineering Record. Sept. 21, 1912.

Means of Egress from Buildings.—In a report made by the National Fire Protection Association Committee on Safety to Life is the following statement:

> "It has long been recognized that the common outside form of iron ladder-like stairway anchored to the side of the building is a pitiful delusion. This device for a quarter of a century has contributed the principal element of tragedy to all fires where panic resulted. Passing successively the window openings of each floor, tongues of flame issuing from the window of any one floor cut off the descent of all on floors above it. Iron is quickly heated and is a good conductor of heat, and expansion of the bolts, stays and fastenings soon pulls the framework loose, so that the weight of a single body may precipitate it into the street or alley. Many a human being has grasped the hot rail of such a 'fire escape,' only to release it with a scream and leap from it in agony. Its platforms are usually pitifully small, and a rush to them from several floors at once jams and chokes them hopelessly. It is a makeshift creation of the cupidity of landlords, frequently rendered still more useless by the ignorance of tenants, covered up with milk bottles, ice boxes and other obstructions."

This powerful arraignment unquestionably is deserved by a very large percentage of the outside fire escapes in use to-day. The following common defects exist on many:

(a) Inaccessible to many portions of buildings, except by going into the halls, which may be impassable owing to flames and smoke.

(b) Unshielded against fire in lower stories.

(c) Poor design, especially as regards steepness and lack of width.

(d) Poor supports. Expansion bolts and even lag screws in wooden plugs have been used to support fire escapes.

(e) Absence of any form of ladder or stair from the second floor to the ground, or complicated and inefficient arrangement of vertical drop ladders.

(f) Poor condition. Fire escapes are generally regarded as a necessary evil, and receive very little attention.

(g) Ice and snow covering.

(h) Used for storage.

Covered by Model Building Code.—Part IX of the Building Code of the National Board of Fire Underwriters covers this subject in great detail; as it is daily becoming more generally recognized that the question of safety to life in the modern factory and office building is one worthy of considerable expenditure of money, and as the treatment of the question in the Building Code covers the subject better than any other description now before the public, this entire chapter is reprinted below. The reference to sections is to other parts of the code. Any section under 44 and over 49 will be found on pages 293 to 349, inclusive.

SECTION 44. NUMBER AND WIDTH OF EXITS AND DOORS.—1. Every building, except dwellings, and every story in each building above the first, shall have at least two means of exit remote from each other; one of these shall open to a street or fireproof passage leading to a street, and one may open to a yard or other space deemed safe by the superintendent and of sufficient area to accommodate all persons in the building. Two means of exit remote from each other shall be provided from each story of dwellings when over three stories in height.

2. In every building except buildings of Class D, all required exit doors in the first story, including the doors of vestibules, shall open outwards. This requirement shall not prohibit the use of doors which swing both inwards and outwards, nor of sliding or rolling doors in stables, garages, storerooms, and the shipping and receiving rooms of manufacturing, mercantile and industrial buildings, where approved by the superintendent.

3. When exit doorways have a clear width of at least 40 inches each, the aggregate widths of such doorways shall be equal to the required width of corridor or stairway served by same. When individual doors are less than 40 inches wide, there shall be one doorway for each 22 inches of required width of corridor or stairway leading to same. Every doorway shall be at least 28 inches wide in the clear. All passageway exit doors shall swing in the direction of exit travel, except in case of horizontal exits where direction of travel may be indeterminate.

All exit doors leading from rooms having an occupancy of 15 or over, shall open in the direction of exit travel, except in schools where fire drills are organized under control of the teachers.

NOTE.—In schools where pupils are trained in fire drill, it is considered essential that classroom doors should open inwards, as they are better adapted to positive control by the teachers in time of panic. If necessary, a teacher can back against a door and hold it until the pupils are in marching order, and the proper time arrives for them to file out.

4. The opening of one door shall not be permitted to obstruct another, and the arc of opening of doors which open upon stairway landings or platforms shall not reduce the width of the passageway to less than the required width of the stairs.

5. Every room having an occupancy of more than 75 persons shall have at least two doorways remote from each other leading to exits.

6. Hallways or corridors at the street or court level furnishing exit from stairways, shall be not less in width than the aggregate width of the required stairways which they serve. Every hallway or corridor which may serve as an exit for 50 or more persons, shall have at least 44 inches of width for the first 50 persons and 6 inches additional for each additional 50 persons to be accommodated thereby. This computation shall be based on the number of persons in the story having the largest occupancy served by said corridor.

7. At all times when any loft or space is occupied for manufacturing or mercantile purposes, the fastenings or locks on exit doors shall be such as may be easily opened from the inside without the use of keys.

8. A clearly painted sign marked "EXIT" in letters not less than 6 inches in height, shall be placed over all exits in the above specified buildings. The elevators shall be provided with similar signs marked "ELEVATOR." Such signs shall be illuminated when necessary by means of artificial lighting. The color of such light shall be green.

NOTE.—It has been customary to designate an exit by a red light, but State and National Safety Organizations have adopted green as the standard color to indicate safety, and red to signify danger. It is therefore consistent that exit signs which betoken safety, should be marked by green lights.

9. Elevators, escalators and revolving doors shall not be considered in calculating exit requirements.

10. Entrances and doors in tenement houses, theatres, motion picture theatres, and places of public or private entertainment, shall be as elsewhere provided.

SECTION 45. STAIRS AND STAIRWAYS, CONSTRUCTION OF.—1. All buildings which are used above the first floor for manufacturing or business purposes, or for public assemblage, or for any purpose whatever if over three stories or 40 feet high, except armories, court houses, dwellings, fire houses, jails, libraries, museums, police stations, prisons, railway stations, and similar buildings, shall have the required stair shafts separately and continuously enclosed, as specified in Sections 90 and 93. In fireproof buildings all stairs, platforms, landings, and stair hallways, including the flooring, shall be of fireproof construction.

Enclosure for stair hallway, same as stair shaft, Sec. 115, par. 7.

2. All stairs, platforms, landings, balconies and stair hallways, shall be of sufficient strength to sustain safely a live load of not less than 100 pounds per square foot for interior construction, and 150 pounds per square foot for exterior construction, with a factor of safety of 4 in each case; and except in dwellings shall conform to all the requirements of this section as to hand rails, newels, landings, widths, exits, and prohibition against winding treads. The space beneath any stairway built in whole or in part of combustible material shall be left entirely open or be completely enclosed without door or other opening.

3. No stories in any building shall be connected by an open shaft or stairway except dwellings and buildings provided in paragraph 1.

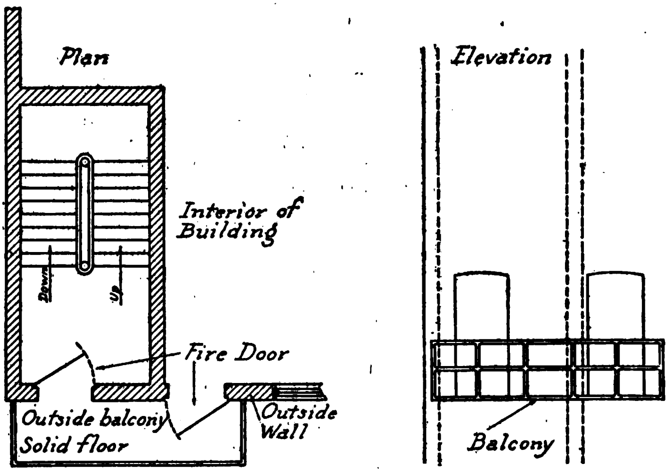
4. Stairways used as required means of exit shall be at least 44 inches wide between faces of walls, or 40 inches wide between face of wall and an open balustrade, or between two open balustrades. All such widths shall be clear of all obstructions except that hand rails attached to walls may project not more than 3½ inches within them. If newels project above tops of rails, a clear width of at least 44 inches shall be provided between the faces of the newel and the face of the wall or newel opposite. All stairs shall have walls or well-secured balustrades or guards on both sides, and except in dwellings, shall have hand rails on both sides. A stairway of 7 feet or more in width shall be provided with a continuous intermediate hand rail substantially supported. All stairs shall have treads and risers of uniform width and height throughout each flight; the rise shall be not more than 7¾ inches, and the tread exclusive of the nosing not less than 9½ inches. Stairways exceeding 12 feet in height shall have an intermediate landing, at least 3 feet in length.

NOTE.—For stairways in primary schools it may be advisable to reduce the height of risers here given.

Buildings in which there may be a congregation of people for civic, political, educational, religious or amusement purposes, except as provided for theatres and in those used for the care or treatment of persons, all stairs exceeding 8 feet in height shall have an intermediate landing at least 3 feet in length.

5. No arrangement of treads known as winders shall be permitted in required stairways between the level of the top floor and the street, excepting in public and other special buildings where the use and arrangement is approved by the superintendent.

Smokeproof Tower with Outside Balcony Entrance



Smokeproof Tower with Vestibule Entrance

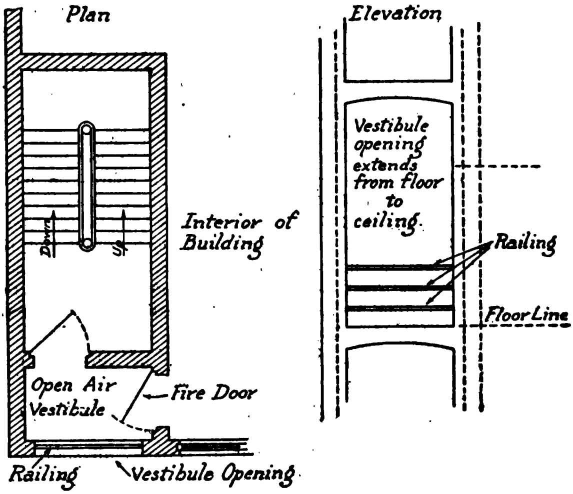


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FIG. 62.—Diagrams showing different arrangements for smoke-proof towers. No direct communication with the building.

6. Whenever the treads or landings are of slate, marble, stone or composition, they shall be supported for their entire length and width by a solid metal plate at least ⅛ inch thick, securely fastened. If stairs are of incombustible material, other than metal, and treads and landings are each solidly supported for their entire length and width by masonry, metal supports for treads may be omitted.

7. All stairways that serve as required means of exit for one or more of the upper four stories of every building shall be continued their full width to the roof, and shall lead by a direct line of travel to the first story, and open directly on the street, or to an open-air or fireproof passage leading to the street, or to a yard or court connected with the street. Such fireproof passage shall be not less than 7 feet in height.

8. The continuity of all stairs which may be used for exit purposes, shall be interrupted at street level by partitions or doors or other means which will make clear the direction of egress to the street.

NOTE.—The purpose of this is to prevent trapping in the basement of people who are trying to escape to the street.

9. Every enclosed stairway shall be provided with an adequate system of lighting, arranged to insure reliable operation when through accident or other causes the regular lighting is extinguished.

10. All required-stairways shall be constructed in one of the following three ways, and shall be known as stair exits:

(a) Enclosed Interior Stairways. The stairs, landings, platforms, and passageways connected therewith, shall be completely enclosed by fireproof partitions of the standard required in Sections 90 and 93, except that no glass panels shall be permitted in the doors in buildings of Class A not exempted in paragraph 1.

(b) Smokeproof Tower. The stairs, landings, and balconies or platforms, shall be solid and completely enclosed as required for interior stairways in Section 90, and shall extend from the sidewalk, court, or yard level, to and above the roof to form a bulkhead. There shall be no openings in any wall separating the stairway from the building, but fixed or automatic fire-windows sufficient for lighting purposes are not objectionable in the exterior walls, provided they are not subject to fire exposure hazard from the same or nearby buildings. Access shall be provided to the stairway from every story of the building by outside baloncies of steel or masonry, or by vestibules within the walls of the building but open on at least one side. Every such balcony or vestibule shall have an unobstructed width of at least 44 inches, and shall open upon an open space not less than 100 square feet in area. The balcony or vestibule shall be provided with a solid incombustible floor. Railings of steel, or other approved incombustible material, shall be provided not less than 4 feet high. Access to the balcony or vestibule from the building and to the stairways from the balcony or vestibule shall be by approved self-closing fire doors not less than 40 inches wide and 7 feet high, which shall swing in the direction of exit travel. The doors shall be provided with locks or latches with visible fastenings requiring no keys to open them. A wired glass panel not exceeding 720 square inches shall be provided in the door opening into the stair shaft. The level of the balcony or vestibule floor shall be not more than 7¾ inches below the door sill of the building. Landings in such stairways shall be of a width that the doors in opening into the stairway shall not reduce the free passage-way of the landing to a width less than the width of the stairway. Figure 62 shows typical arrangements for smokeproof towers. Figures 64 to 68 are photographs illustrating different architectural treatment of exterior balcony connection to smokeproof towers.

NOTE 1—It is recommended that the balustrades enclosing the balconies of smokeproof towers be of sheet metal or other suitable solid material. This would give confidence to the timid, and afford valuable protection from smoke and flames issuing from a door or window beneath the balcony. For the same reasons, the balustrades of outside exit stairways, where directly over or near wall openings, should be enclosed in the same manner.

NOTE 2—The use of a smokeproof tower or stairway is recommended as one of the best-known means of safe escape from a burning building. At the same time it provides a protected position from which firemen can attack a fire on any floor.

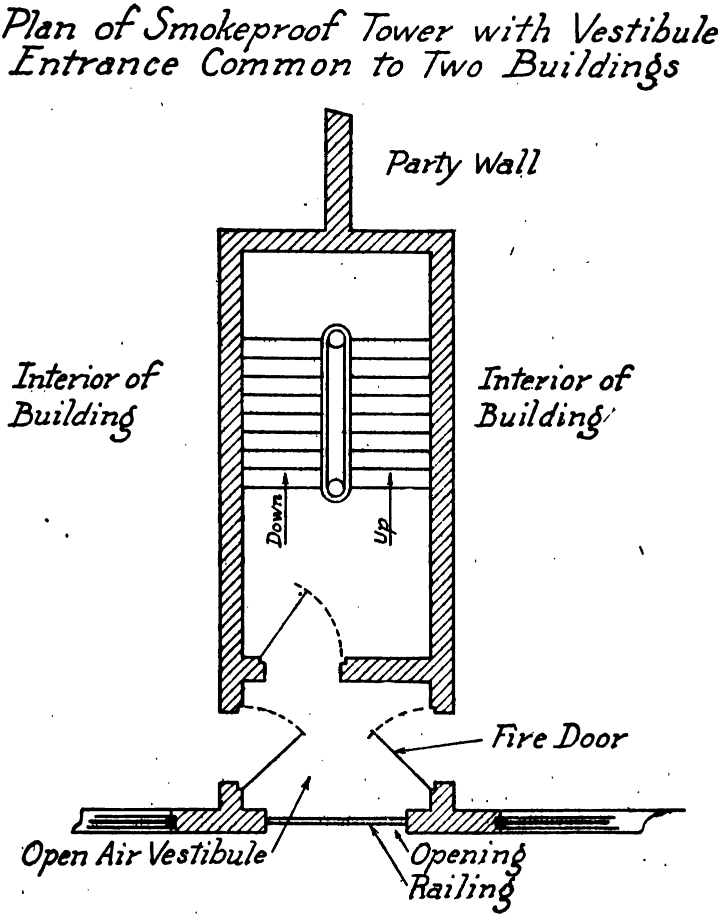

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FIG. 63.—Diagram of smokeproof tower adapted for use of two adjoining buildings

(c) Outside Exit Stairways. Such stairs shall be connected to each story by means of an approved self-closing fire door and incombustible balcony. The door shall be not less than 40 inches wide, and the balcony shall be the same width as the stairs. All wall openings within 10 feet of such stairs shall be protected by approved self-closing fire doors on doorways, and automatic or fixed fire windows on window openings. No riser on such stairs shall be nearer than 4 feet to any such wall opening, except to doors giving access to the same. Metal mesh or other rigid guards at least 4 feet high shall be provided on each side of such stairway throughout. Figs. 69 to 73 illustrate different methods of construction. Provisions shall be made to properly drain the stairs and landings.

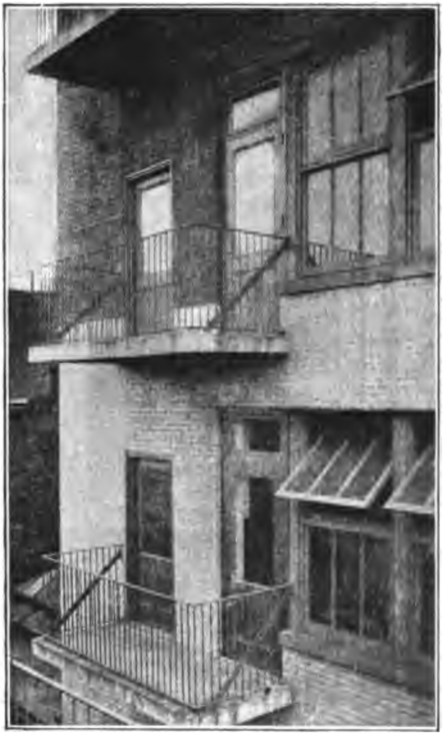

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FIG. 64.—Smokeproof tower with outside balcony entrance. Note solid platform, an excellent construction.

NOTE 1—It is very important that outside exit stairways be so placed that they are not in front of or over windows. Although the windows be protected by wired glass, the heat radiated through them from a fire in the building might easily make it impossible for people to pass, and there is always the added danger of flame and smoke from a window which for some reason is open. If such windows are strictly necessary, the stairway should be set away from the building not less than four feet, as required. Portions of such stairways over or near windows should be made solid, and additional safety for travel in cold and wet weather would be secured by making all treads and landings with non-slipping surfaces.

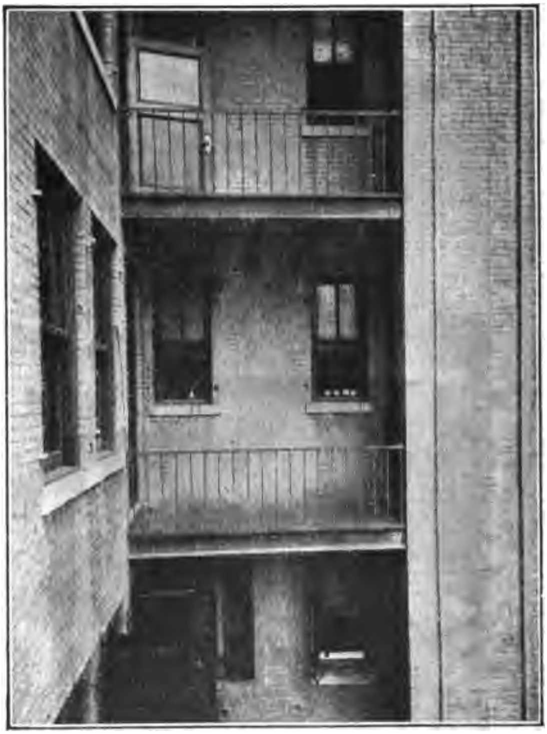

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FIG. 65.—Smokeproof tower (on the right) connected to building by open balcony. Arrangement is good, except the windows opening upon the balcony, and the metal grating flooring.

NOTE 2—The ordinary so-called "fire escapes," consisting of steel-framed balconies attached to a wall and connected by narrow steel ladders or steps leading from openings in the floors of the balconies, are considered very inefficient and unsafe means of exit. If any considerable number of people attempt to use such an exit in time of fire panic, it quickly becomes so congested that travel is very much impeded or entirely blocked. If fire occurs on the floor below that from which people are endeavoring to escape, and the windows facing such exit are not protected by wired glass, the fire escape is worthless; and even with wired glass the exit is of doubtful value because of the intense heat which radiates through the windows. Such means of exit should never be permitted except upon existing buildings, where the number of people to be accommodated by them is small, and where structural conditions are such that it is impossible to secure anything better. They are not recognized as a required means of exit in this code.

The horizontal exit and the three types of stairways specified in section 45 are all efficient and safe means of exit. The outside exit stairway is the least desirable of the four, since when wet or covered with ice or snow it is more difficult to travel. A roof over the stairway would lessen this defect. Completely enclosing the stairway would render it nearly as efficient as a smokeproof tower.

Horizontal exit, Secs. 46, par. 2, (c), and 47.

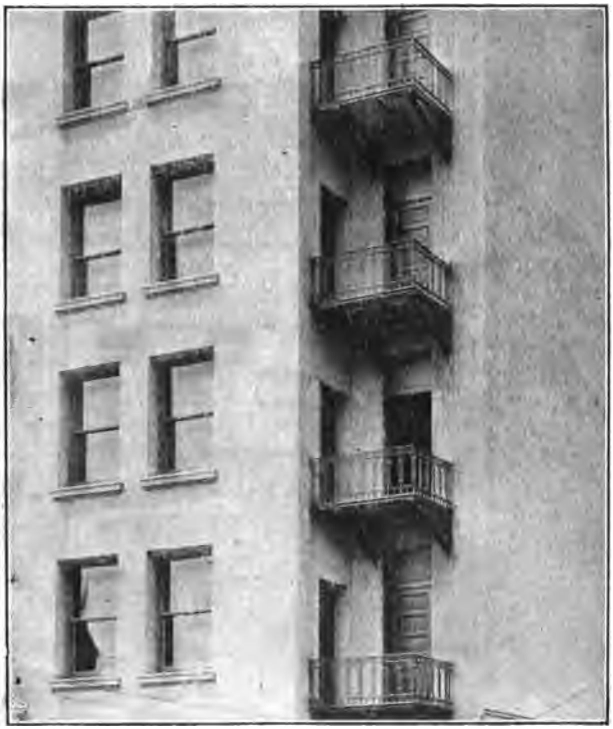

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FIG. 66.—An artistic arrangement of a smokeproof tower, which does not disfigure a building

The Committee on Safety to Life of the National Fire Protection Association reports:

Except they be enclosed in a tower, outside stairs, even if well designed and erected, are not recommended on buildings over six stories in height. The fundamental reason lies in the timidity of persons at a considerable height, no matter how safe the conditions may actually be.

Also that:

After being erected, outside stairs shall be painted.

Outside stairs shall be scraped and painted at least once a year thereafter.

Outside stairs shall be kept clear of incumbrances.

Outside stairs shall be promptly cleaned after snow or ice has accumulated upon them.

No obstructions such as lighting or telephone wires, shall be permitted on or near outside stairs.

Particular attention should be paid to possible interference by awnings at windows or over sidewalk, and to other obstructions at or near the street level.

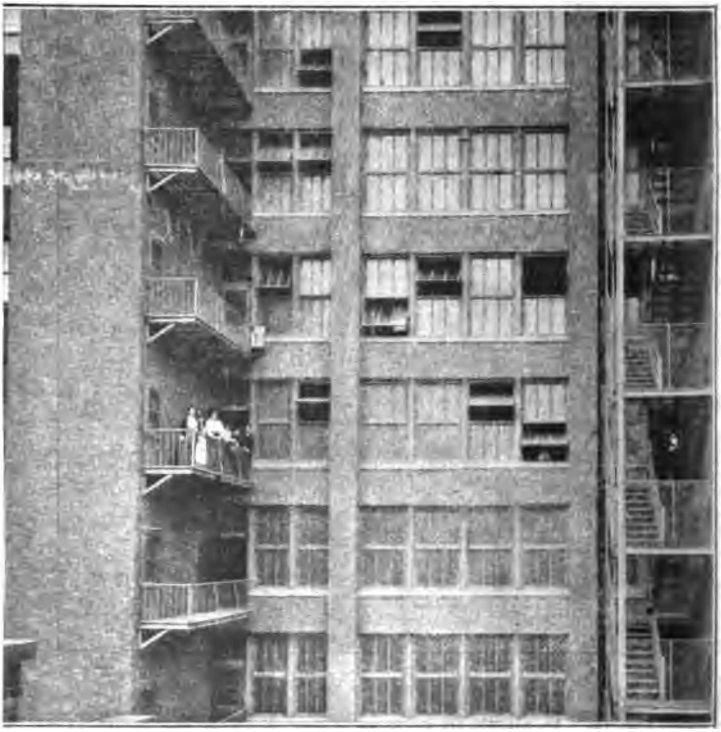

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FIG. 67.—An excellent arrangement of two types of approved emergency fire exits communicating to the same building. Smokeproof tower on the left, and outside stairway on the right. Solid floors would be an improvement.

SECTION 46. REQUIREMENTS FOR EXITS AND STAIRWAYS.—1. Every building hereafter erected, and every building altered or converted to increase its

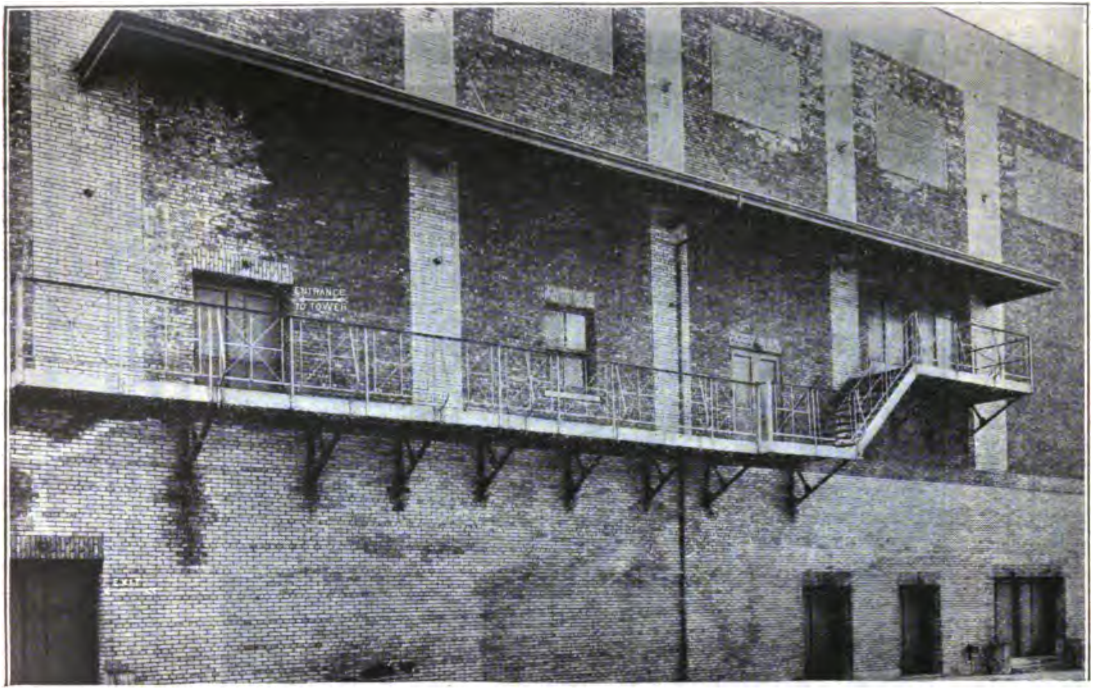

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FIG. 68.—Smokeproof tower exit as applied to small theatre. Furnishes safe exit and avoids obstruction of sidewalk.

occupancy, excepting dwellings, tenement houses, theatres, and assembly halls, which are elsewhere provided for, shall have exits and stairways as required in this section.

2. (a) The term *floor area* in this section shall mean the entire space in a given story between exterior walls, fire walls or fire exit partitions, except that in computing such area the space occupied by walls, partitions, columns, and all shafts may be excluded.

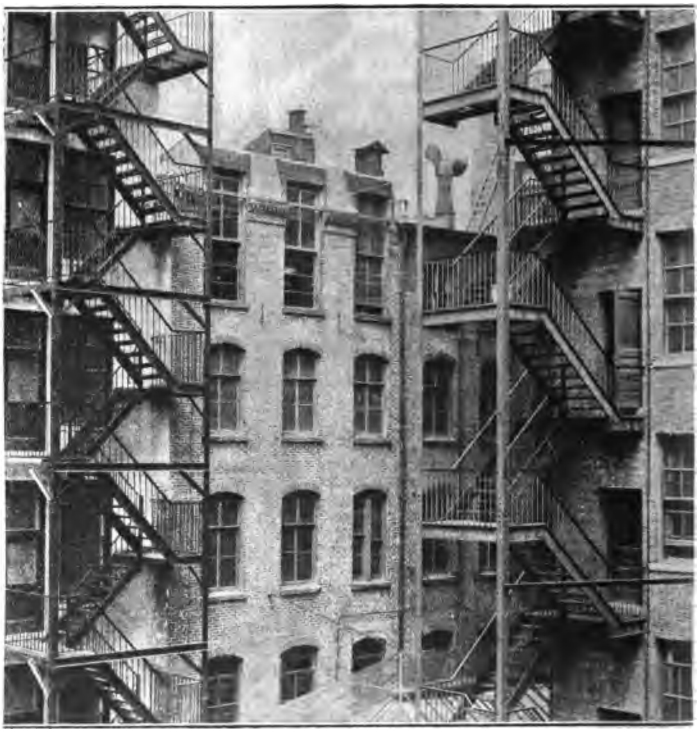

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FIG. 69.—Two types of outside exit stairways. One with stair flights parallel, and the other at right angles to the building. The former has the defect of windows facing the stairway. In time of panic, such stairs would be safer if constructed with risers.

(b) The term *stair exit* in this section shall be as required in paragraph 10, Section 45.

(c) The term *horizontal exit* shall be understood to mean one or more openings through or around a fire wall, fire exit partition, or any wall separating two buildings; no such opening shall be less than 30 inches wide: Or such an exit may be an exterior bridge or balcony connecting two buildings or two floor areas of the same building. Where there is a difference in level between connected buildings or floor areas, gradients shall be provided of not more than 1 foot in 6 feet where practicable. The bridges or balconies shall be not less than 44 inches wide, and shall be constructed of incombustible material, and enclosed on the sides at least 4 feet high. All exterior exposing openings in connected buildings or floor areas within 10 feet of bridge or balcony shall be protected by fire doors or fire windows with fixed or automatic sash. The floor of a bridge or balcony shall be not more than 7¾ inches below the door sill opening upon it; the connecting floor within the building shall be not more than 1 inch below the sill. Every such bridge or balcony when enclosed shall be provided with means for lighting.

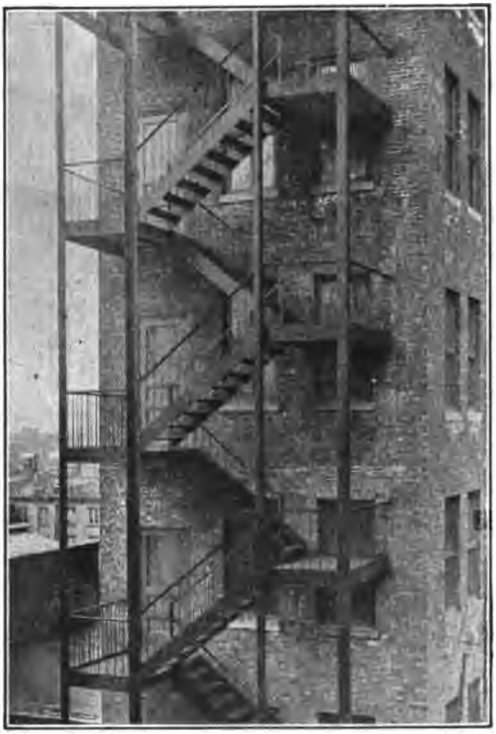

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FIG. 70.—Another method of outside exit stairway construction. Compare framing with similar stairway on left of Fig. 69. The windows opening upon both stair flights and landings are a serious defect.

Fire exit partitions to provide horizontal exits, Sec. 47.

Fire walls as horizontal exits, Sec. 29, par. 4.

All horizontal exits shall be provided with self-closing fire doors. Such doors shall be kept unlocked during the occupancy of any portion of the floor areas or connected buildings. No glass shall be used in such doors when used on exits through fire walls as provided in Section 29, paragraph 4. Wired glass may be used in doors in other horizontal exits provided it conforms to the requirements of Section 47, paragraph 4.

Requirements for self-closing fire-doors, Sec. 29, par. 4, Note.

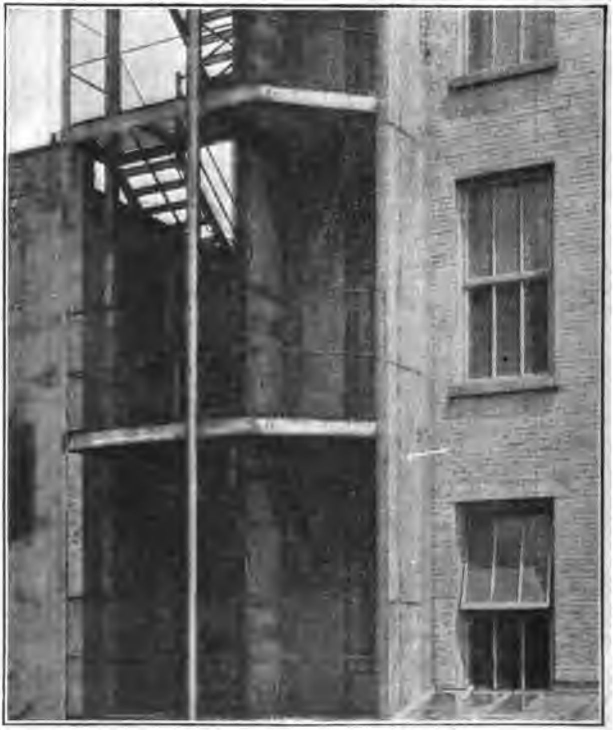

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FIG. 71.—Very safe arrangement of outside exit stairway. Arrow indicates a metal guard plate 3 feet wide erected to protect landings from flames that might issue from windows.

The available floor area on each side of a horizontal exit shall be sufficient for the joint occupancy on the basis of not less than 3 square feet of unobstructed space per person, and shall be provided with at least one stairway as defined in Section 45.

NOTE.—As a means of rapid and safe egress from a burning building, the use of horizontal exits through or around a fire wall or a fire exit partition are very strongly recommended. Such an exit would afford an area of

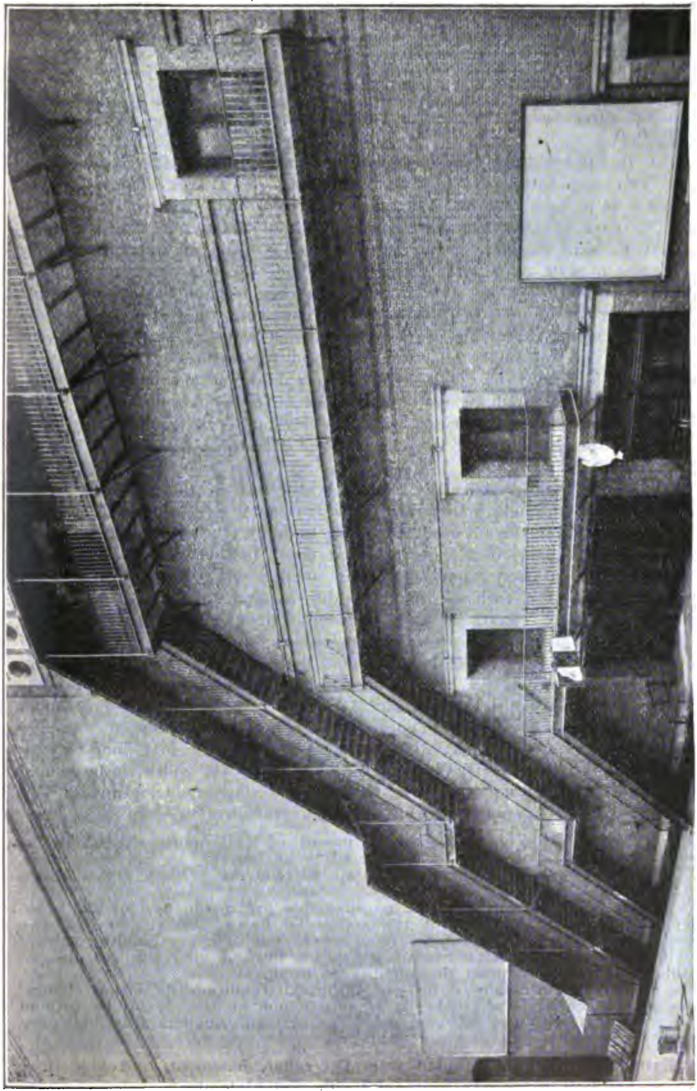

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FIG. 72.—Outside straight-run stairways as applied to a theatre. Note bracket method of support, and protecting hood.

quick refuge upon either side. An important feature of the horizontal exit is that it removes necessity for hasty flight down long stairways in case of fire. The physical effort of hurrying down stairs from a height of even eight or ten stories is excessive, especially for those who are not strong. In still higher buildings there is always danger of stairways becoming blocked by people collapsing from exhaustion before reaching the street level. Much of this danger is removed when people know they are safe.

The efficiency of a horizontal exit as a means of escape from fire, is considered three times that of an equal width of stairway. See Note in paragraph 6.

3. (a) In all buildings not exempted in paragraph 1 of this section, one of the two required means of exit from every floor area above the first floor shall be a stair exit, and the other may be a stair exit or a horizontal exit. No part of any floor area above the first floor, excepting buildings of Class F, shall be more than 100 feet distant from an entrance to one such means of exit.

When a building over 35 feet in height is occupied for business purposes on the lower floors and for the home of not more than two families on the floors above, at least one continuous enclosed stairway shall be provided to the street level through the stories occupied for business.

(b) In buildings of Class E, over 55 feet high, except office buildings, one of the two required means of exit shall be either a smokeproof tower or an interior enclosed stairway with self-closing doors opening into hallways which are also enclosed with fireproof partitions as specified in Section 115, paragraph 1.

(c) In every building over 90 feet in height one of the required means of exit shall be a smokeproof tower or a horizontal exit as herein defined.

4. In determining the occupancy of any building, the width of stairways required for any floor area above the first floor shall be determined by the number of persons occupying such floor area, computed on the basis of fourteen persons for each 22 inches width of stairway, plus one person for every 3 square feet of hallway floor and stairway landings in the story height of such floor, excepting that in any building where a system of automatic sprinklers is installed throughout the entire building, the number and width of stairways may be computed on the basis of twenty-one persons for each 22 inches width of stairway; and excepting that when horizontal exits are provided as required in paragraph 2 (c) of this section, the number and widths of required stairways for floor areas above the first floor may be diminished to a basis of fifty persons for each 22 inches width of horizontal exit, provided that in no case there shall be less stairway or means of exit than required in paragraph 3, (a) and (b) of this section.

Note.—In all building codes the treatment of exits must necessarily be largely theoretical until more systematic study of the subject has been made, and the correctness of conclusions based thereon have been demonstrated under practical service conditions.

As a fundamental principle, exit requirements are a function of the occupancy of a building and not of the area. To promote safety to life, two means of egress should be required from every floor of every building subject to exit specifications, irrespective of its area. Beyond this, exit calculations should be based solely upon the number of occupants.

The method herein employed for computing exit requirements, is not claimed to be all that could be desired. It is an attempt to provide safety without too drastic demands, and is based upon the best information available. Experience may prove that changes should be made.

5. Exits shall also be provided from the cellar, basement, and first story of every building as may be required by the superintendent.

Note.—In buildings where large numbers of people are employed it is urged that fire drills be organized and practiced frequently enough to keep the employees familiar with their operation. The employees should also be taught that when once they have entered an enclosed stairway, or passed

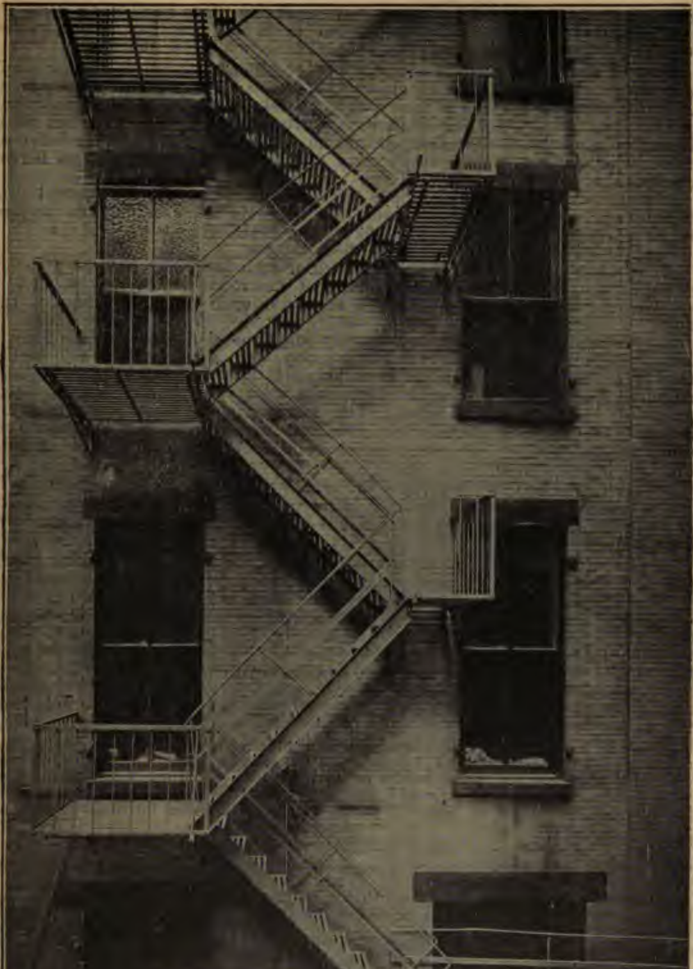

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FIG. 73.—Outside balconies and stairway with balanced flight at the bottom. Stairways of this type permissible on existing moderate height buildings where occupancy is not large. Windows protected by wired glass in metal frames.

through a horizontal exit, they are safe, and can then proceed leisurely to the street with no necessity for undue haste or crowding. Conspicuous notices explaining these facts should be posted in all exit stairways.

SECTION 47. FIRE EXIT PARTITIONS.—1. Partitions, erected to furnish horizontal exits, shall be built of fireproof materials. No construction shall be used for such partitions less than 5 inches thick, unless it has been approved after a fire test; in no case shall such partition be less than 4 inches thick if of block or tile construction, or less than 3 inches thick if of reinforced concrete or solid metal lath and cement plaster construction, except as herein permitted for non-fireproof buildings.

When tile or block partitions are less than 5 inches thick, substantial protected reinforcement shall be provided at intervals not exceeding 20 feet in length to resist the effect of buckling due to heat.

Requirements for horizontal exits, Sec. 46, par. 2, (c).

2. Fire exit partitions shall be supported at each floor, and shall be securely anchored to the walls, floor, and ceiling of the rooms which they subdivide. In fireproof buildings such partitions shall rest upon the fireproofing of the floor.

3. In non-fireproof buildings five exit partitions shall be not less than 3 inches thick if of block or tile construction, and not less than 2½ inches thick if of reinforced concrete or solid metal lath and cement plaster construction, and shall be continuous through all stories of the buildings and be placed one above the other. The space between floor joists included between the top of a partition in one story, and the bottom of the corresponding partition in the story above, shall be completely fire-stopped with incombustible material.

Fire-stopping of partitions, Sec. 97, par. 3.

NOTE.—In non-fireproof buildings it is recommended that fire exit partitions be of masonry construction not less than 8 inches thick, extending continuously from cellar to roof.

4. Doorways in fire exit partitions shall be not more than 60 feet apart, but doorways may be omitted if approved means of exit around the partitions are provided. No openings other than doorways protected by fire doors, shall be placed in such partitions except that fire windows not exceeding ½ of 1 per cent of the area of the partition may be permitted where strictly necessary for purposes of observation. Such fire windows shall have fixed sash, and may be placed either in the partition itself or in the doors. Windows placed in partitions shall also be protected by automatic closing fire shutters. No single pane shall exceed 144 square inches in area, and not more than one pane shall be placed in a door.

NOTE 1.—The amount of glazed surface in such partitions should be kept as small as possible owing to the danger that in case of fire, the heat radiating through the glass would make the area of refuge untenable before the people who fled to it, could escape by other exits. There would also be the added danger of panic if a large portion of the burning area were freely exposed to view.

NOTE 2.—To promote safety to life it is recommended that buildings of Class C, also office buildings and tenements, should not have above the first story, floor areas in excess of 2,000 square feet without providing a horizontal exit. In buildings of that type this provision can be easily and inexpensively accomplished in a variety of ways.

SECTION 48. EXITS AND PROTECTION FOR EXISTING BUILDINGS.—1. Where the exit facilities of existing buildings are found by the superintendent of building construction to be inadequate, additional exits, sprinklers, or other protection shall be provided of approved types.

NOTE.—The construction of fire exit partitions to provide horizontal exits in existing buildings, is probably the simplest, cheapest, and most efficient method of affording real safety to occupants in case of fire. They are particularly applicable to floor areas where many persons are employed or liable to congregate, also in the upper stories of buildings where outside succor would be difficult or impossible. See Note, Sec. 46, par. 2, (c).

SECTION 49. ENGINEERS' STATIONARY LADDERS.—Every building in which high-pressure steam boilers are placed in the cellar or lowest story shall have stationary iron ladders or stairs from such story leading direct to a manhole through the sidewalk or other outside exit in addition to another approved means of entrance and exit.

SIGNALLING SYSTEMS

Ranking only slightly below automatic sprinkler systems as a life-saver and property guardian against fires are the various signalling systems. These are of several kinds and combinations, from simple gongs or whistles which can be pulled from different places in the plant to the modern automatic system operated by thermostats.

Whatever form of signalling system is adopted, if it depends upon a human agency to put it in operation, it is of vital importance to impress upon every one in the plant that the *first duty* on the discovery of a fire is to *make sure the fire alarm has been sent in,* and only after that to attempt to extinguish the fire. Delayed alarms have been the cause of many of the holocausts of recent years. A few seconds quicker sounding of the alarm often means the lives of many of the workers, and generally means saving the plant, as notwithstanding how well trained and powerful the private brigade is, the help that can be obtained from the public fire department is often inestimable.

Interior Fire Alarm Service

Auxiliary fire alarms come under the head of private fire notification, and form a very valuable adjunct to the municipal systems. The necessity of having alarms transmitted promptly to the fire department by whoever discovers fire would seem to be self-evident, and yet comparatively little attention has been paid to this feature as regards ability to send out the alarm from inside the risk. In a few cases we find that a private city fire alarm box has been installed, but this is not common. Much ingenuity as well as money has been spent on the fire department house and its appurtenances to save every second possible after alarm has been received; also, as regards the city fire alarm system, that no delay may be occasioned after alarm box has operated; but when we come to the risk itself we find, as a rule, no means of using to best advantage the public alarm or the fire department, owing to the fact that whoever discovers fire frequently must waste several valuable minutes in reaching the fire alarm box, which may be several blocks distant. Even supposing there is a fire alarm box at risk, the fire may be located at some distance from the box, as on the top floor of a high building, or in some other building of the risk, necessitating a considerable delay where seconds count. The auxiliary fire alarm system largely eliminates this defect, and its use should, therefore, be encouraged. The system is simple, and when properly installed with auxiliary boxes located on each floor and at such points that not more than 200 feet will have to be traversed in order to reach a box, we have a device which will save valuable time at the start, and thereby we can make full use of the public fire department, which is maintained at a great expense and able to render efficient service if promptly notified of fire.

Pneumatic and Electric Thermostat Systems

Of the greatest value in any plant must be placed the thermostat signalling system; these are ever on the watch for a fire and if properly maintained can be counted upon to sound alarms for fires one or two minutes before sprinklers operate and in many cases quite a time before the fire would be discovered by a watchman in his rounds. One of the disadvantages to a system of this kind has been that thoroughly reliable thermostats had not been brought out. Only in recent years have any been approved by the Underwriters' Laboratories, and the unapproved ones have given much trouble on account of false alarms and other trouble.

Every hazardous-process plant, and all having many employees whose life would be endangered by fire should be equipped with thermostat alarm systems. It is probably only a question of time before these will be required by law in department stores, loft buildings and many factories.

The Underwriters' Laboratories list two types of thermostat systems, pneumatic and electric; the first is known by the trade name of "Aero" when sold by one company and "Compensating" by another company; the electric are the "May-Oatway" and the "Reichel." These are described as follows:

PNEUMATIC THERMOSTAT.—These systems utilize the principle of the expansion under heat of air contained in a small copper tube which is installed along ceilings or pipings. Tube leads to contact-closing and test devices of special type. The expansion of air in tube actuates a diaphragm closing an electric circuit whereby signal is transmitted.

These devices as sold by the manufacturers are standard subject to the following conditions:

1. Inspection departments having jurisdiction to be consulted in all cases before installations are made.

2. Tubing to be installed to comply as to location, distribution and spacing with the following requirements:

a. Each circuit having but one electrical contact device must consist of a continuous length of tubing not exceeding 1,000 feet in length, without branches or alternative paths.

b. Where two or more electrical contact devices are connected to a single line of tubing one such device must be placed not more than 1,000 feet from each end of the tubing circuit, and adjacent contact devices must not be more than 1,500 feet apart.

c. Where necessary, tubing must be protected against mechanical injury as may be required by the Inspection Department having jurisdiction.

d. Tubing must be enclosed in conduit, or otherwise insulated or lagged where this is necessary in order properly to isolate the signals on the annunciator.

e. In every enclosed space or separate room there must be at least two and one-half per cent of the total length of the tubing comprising the circuit where only one electrical contact device is used, or two and one-half per cent of the length of tubing between any contact device and an end of the circuit, or of the length between adjacent contact device where more than one per circuit is used.

f. In no case shall less than 10 feet of tubing be used in any enclosed space or separate room.

g. Lines of tubing shall be so disposed throughout the area to be protected that they shall be not more than 30 feet apart, and so that no point on the ceiling will be more than 15 feet from the nearest point of the tubing.

h. Tubing may be run either directly on ceilings, or on side walls, if the tubing is placed not more than 20 inches below ceilings, or on the lower sides of timbers or projections.

i. In rooms where timbers or other projections form bays more than one foot deep, each bay must be treated as a separate fire area.

3. Central station equipments, local equipments, electric devices and circuits and other portions of this system other than the tubing and the pneumatic devices connected with it to comply in all respects with the general requirements for automatic fire alarm systems.

4. Labels.—Tubing for these systems constructed according to standard specifications and inspected at factory under the supervision of Underwriters' Laboratories, bears tag reading: "Underwriters' Laboratories, Inc., Inspected Tubing for Automatic Fire Alarm No. .... (50 feet). This tag must be preserved after tubing is installed." One such tag for each length of tubing installed should be preserved in transmitter case at risk as permanent record of tubing used. Each detector, annunciator and transmitter for this system constructed according to standard specifications and inspected at factory under supervision of Underwriters' Laboratories, bears label reading as above.

ELECTRIC THERMOSTAT.—Electric, closed-circuit central-station systems, with detectors, transmitting, recording and testing devices. Central station and local equipments, devices, circuits and portions of these systems other than detectors or thermopiles to comply with the general requirements for automatic fire alarm systems.

Labels.—Each indicator set, detector, thermopile, transmitter, manual box, and central station relay constructed according to standard specifications and tested under the supervision of Underwriters' Laboratories bears a label.

May-Oatway.—The thermostat or detector of this system consists of a copper wire hung beneath a steel bar and provided with an electric contacting device at its middle point.

Detectors to be installed to comply as to location, distribution and spacing with the following requirements: Maximum floor area for one 7½-foot detector, 750 square feet. Maximum floor area for one 5-foot detector, 500 square feet. Maximum distance apart between detectors, in general, 40 feet; in corridors, 60 feet. Maximum distance between centers of detectors nearest walls and such walls, 20 feet (30 feet from ends of corridors).

"Reichel."—This system employs thermopiles of special design connected in a series circuit with special alarm, testing and transmitting devices. Current generated in the thermopiles by heat resulting from a fire actuates the transmitting device. Thermopiles are to be installed to comply as to location, distribution and spacing with the following requirements: Maximum floor area for one thermopile, 400 square feet. Maximum distance apart between centers of thermopiles, in general, 25 feet; in corridors, 40 feet. Maximum distance between centers of thermopiles nearest walls and such walls, 10 feet (20 feet from ends of corridors).

As a safeguard against water damage especially, and also to enable a quick response of the fire department in case it is needed, every automatic sprinkler system should have a sprinkler-flow alarm system provided. Also to ensure the proper maintenance of the sprinkler system, the supervisory alarm is absolutely necessary.

As mentioned above, an early notification of the public fire department is of vital importance; the use of manual fire alarm system or auxiliary service to a street fire alarm box furnishes ready means of obtaining this and is usually considerably cheaper than some of the other forms. This auxiliary fire alarm service is used extensively in all the larger cities, particularly in office buildings and large factories, where someone is usually available at all times; its service is very satisfactory where the apparatus is properly maintained. Although recognized by the underwriters by a reduction in rates in many parts of the country, no regulations have been issued by the National Board of Fire Underwriters covering its use or installation.

In the preamble to the requirements issued by the National Board of Fire Underwriters for other signalling systems, which are given below, it is stated that:

Especial importance is placed upon the methods employed in testing, inspecting and maintaining signaling systems. None of these systems is sufficiently automatic to do away with the necessity for periodical inspections and working tests of all of their parts. Such systems must be under the supervision of a responsible person, satisfactory to the municipal authorities and the Inspection Department having jurisdiction, who shall cause proper tests and inspections to be made at frequent intervals and have general charge of all alterations and additions. Records of such tests and inspections should be kept accessible to the Inspection Department and others interested.

SIGNALLING SYSTEMS*

Part I

Class A—Wiring for all Systems

NOTE.—For other rules governing wiring for signaling systems which are hazardous only because of their liability to become crossed with electric light, heat or power circuits, reference should be made to the "National Electrical Code."

1. UNDERGROUND WIRES.—To secure the largest measure of safety and efficiency in the operation of signaling systems all wires outside of buildings should be placed underground.

2. AERIAL WIRES.—Where from the nature of the case it is impracticable to place wires underground the following rules must be observed:

a. Must be equipped at points where they enter buildings with approved heavy current protectors.

b. Must be equivalent in conductivity and tensile strength to No. 14 galvanized iron (12 B. & S.) where single wires are used, and to No. 16 B. & S. hard drawn copper where cables are used.

c. Must have an approved insulating covering. Line wires must have a good weatherproof covering, consisting of a thoroughly saturated and filled braided covering at least 1/32 inch in thickness. Wires in cables to have same covering as single wires and in addition a substantial filled covering around the several wires. Service wires to building and boxes must have an approved rubber covering. See list of Electrical Fittings.

d. Must, when strung on poles, be supported at least every 150 feet, and as far as possible, run under rather than over electric light and power wires.

Where wires are carried along the outside walls of buildings, they must have an approved rubber insulating covering, and must be supported at least every 12 feet.

3. WIRES INSIDE BUILDING.—a. Must be equivalent in conductivity and tensile strength to No. 16 B. & S. copper wire where single wires are used, and to No. 18 B. & S. copper wire where cables are used.

NOTE.—For the wiring in Central Stations—Sections "c" and "f" may be modified as circumstances demand.

b. Must have an approved covering, consisting, except as noted below, of a rubber insulation at least one thirty-second of an inch in thickness and a substantial braid both constructed in accordance with the National Electrical Code for rubber wire. For open work in dry places and for tubing and wooden moulding a filled braided covering at least 1/32 inch in thickness may be used.

c. Unless encased in approved tubing or thoroughly filled moulding must, except as hereinafter provided, be run in plain sight and entirely supported on non-combustible insulators placed not more than 8 feet apart, and so arranged that the insulating covering of the conductors will come in contact with no other substances than the designed supports, the protecting bushings and the connecting instruments.

d. Must be protected from abrasion and from accidental contact with other conductors. Where subject to severe mechanical injury, substantial boxing or iron conduit must be used on side walls, otherwise approved moulding may be used. Wires should be run over rather than under pipes, and their coverings must be separated from contact with all pipes by a solid insulating substance creating a separation of at least ⅛ inch. Special attention must be paid to the mechanical execution of the work. Careful and neat running, taping of wire, and attaching and securing of fittings are required.

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* Regulations of the National Board of Fire Underwriters.

e. Must be installed as far as possible without joints. Where joints are necessary, they must be mechanically and electrically secure, and covered with an insulation equal to that on the conductors.

f. Must, in bay construction, follow contour of ceiling, and not be strung from beam to beam. In joisted construction, unless run parallel with joists, must be placed in moulding or have a 4-inch wide wood backing strip with knobs or cleats fastened to the bottom of this strip.

g. Must, where exposed to mechanical injury, and between batteries, transmitters, testing apparatus, annunciators, bells, etc., be enclosed in boxing, moulding or approved conduit.

h. Must, when passing through iron, brick, stone or any damp partition or through any floor, be protected by approved bushings.

NOTE.—Glass and porcelain are approved for bushings. Where from the nature of the case, it is impossible to use glass or porcelain, approved flexible tubing may be used. See list of Electrical Fittings.

Class B—Energy for all Systems

4. CENTRAL ENERGY.—The following sources of energy are given in their order of preference:

1. Storage Batteries.—To be in duplicate sets, each set capable of operating the system at full capacity for 60 hours, installation to be in a room provided with suitable ventilation and effectually separated from that containing other fire alarm apparatus.

Cells should be mounted on glass and porcelain supports, secured to metallic frames suitably protected from corrosion, except that when cells too large to be so mounted are used, such cells may be mounted on suitable glass insulators.

At least two reliable independent sources of charging current to be provided. It is preferable that the voltage of the charging circuit be not over 250 volts. Batteries to be protected by approved enclosed fuses in tight metal cabinets at the battery terminals.

NOTE.—It is recommended that all copper conductors in battery room be coated with lead—applied directly on the copper.

Suitable provision to be made on a switchboard for charging the batteries, with approved means of protecting them against injury due to interruption of charging current, to reverse charging current or to excessive rate of charge; also provision for shifting the respective batteries from charging to working and from working to charging without opening any of the working circuits during the process of shifting, and so that charging current cannot be accidentally connected to any of the working lines during the process of shifting.

2. Motor Generators.—A sufficient number of motor generators to be provided to supply all circuits without overloading any machine, and with a reserve capacity equivalent to one-half of the total capacity of the station. Motor generators to be driven from all available independent exterior sources of energy, and also by a special generating plant in the headquarters building, driven by some form of prime mover constantly available for immediate operation.

With either battery or motor generator source of energy, the voltage applied to maintain normal line current on circuits must be such that the line current will not be reduced below safe operating value by the simultaneous action of eight (8) transmitters.

5. LOCAL BATTERIES.—In cities having a complete system of underground distribution for electric light, heat or power, the Inspection Department having jurisdiction may permit connection with such system in lieu of local batteries.

a. Must be located in a place favorable to their operation and maintenance.

b. Must be enclosed to prevent mechanical injury, but be readily accessible for inspection.

Class C—Central Stations

Before acceptance is obtained for any equipment operating through a central station, the company must file with the Inspection Department having jurisdiction, a general description of the apparatus it proposed to install, together with such detailed information, and drawings as are necessary to the complete understanding of the operation of the system. It must also furnish such daily reports to its customers and the Inspection Department having jurisdiction, as may be required.

If the Inspection Department requires it, the operating company shall also furnish:—

First.—Diagrams showing the manner in which it proposes to connect the various equipments to its central station and deliver signals to the patrol and city department.

Second.—A satisfactory guarantee as to its ability to render this service and as to the maintenance and efficiency of its system.

6. HEADQUARTERS.—a. Must be located in a building provided with fire protection, satisfactory to the Inspection Department having jurisdiction, and be equipped with the necessary instruments of an approved pattern for automatically receiving and recording all signals. The time of the receipt of signals must also be recorded, preferably by an automatic device.

b. Must have at least two competent men on duty constantly, and in addition, maintain a runner service so arranged that any building protected can be reached within 15 minutes.

All runner service maintained must be sufficient so that the two operators will always be in attendance, except that only in an extreme case one of the operators may be used as a runner. All runners shall be of mature age, and one such man shall also be in charge of the central station.

c. Must have two independent means of transmitting alarms to the fire department.

d. One approved hand chemical extinguisher and six sand pails to be provided for each 2,500 sq. ft. of floor area. When any portion of the building is occupied as a stable, garage, machine shop or for storage purposes used in connection with the maintenance of the system, the part thus occupied to be protected by an approved system of automatic sprinklers.

DEVICES, CIRCUITS, ETC.—a. Must be designed and installed so as to successfully meet the most severe conditions obtained in practice and no change nor alteration shall be made in same without approval.

b. Must be arranged so that interference of signals will be impossible under any conditions likely to be met in practice.

c. Must automatically register at the central station distinctive trouble signals when any part of the wiring system is grounded, broken or impaired, so as to prevent the normal operation of the system.

d. Must, from the risk to the central station, under normal conditions, employ complete metallic circuit for the transmission of signals and depend upon an earth return circuit, if at all, only for transmitting trouble signals, except that where fire signals are transmitted over two independent circuits by the same piece of apparatus, the two circuits may have earth return.

e. Must be arranged to receive, record and transmit to fire department and insurance patrol the box number of the building from which an alarm has been received.

f. A terminal board of slate or marble must be provided. Each side of each entering circuit must be equipped with protectors especially approved for this service.

g. Approved automatic devices to be provided, by means of which openings of circuits will be immediately announced by visual and audible signals. Manual tests of all circuits to be made at least four times during each 24 hours.

In every case facilities must be provided for making the following test—current strength on each circuit; this current to be adjusted to normal before making the other tests. Voltage across terminals of each circuit at the inside terminals of protective devices. Voltage between ground and each side of each circuit. Voltage between positive side of each circuit and negative side of all other circuits.

Class D—Manual Fire Alarm Systems

8. BOXES AND MANUALS.—a. Must be of an approved type; be used for no other purpose, and must be arranged to give a signal from each box or manual.

NOTE.—A box such as is approved for Central Station Night Watch and Fire Alarm Systems may, however, be used if desired.

b. Must be located near all main exits and, in addition, must conform to the following:

1. Must be located so that from any part of the plant equipped not more than 200 feet will have to be traversed in order to reach a box.

2. Must, where buildings are more than one story in height, have a box on the first story, and at least one in alternate stories; i. e., 3d, 5th, 7th, etc. Where buildings have single floor area of 7,500 square feet or over, there shall be at least one box on each floor.

NOTE.—If risk has multiple tenant occupancy, Inspection Departments may require additional boxes to those called for above.

3. Must, where any plant or building equipped is divided into sections, have the boxes in each section to agree with above rules, account not being taken of the boxes in any other section.

c. Not over 40 boxes or transmitters shall be permitted on a single circuit.

EDITOR'S NOTE.—This was amended in 1916 to permit 50 boxes.

9. TESTS.—All boxes to be tested at least monthly, a record of these tests being made.

Class E—Automatic Fire Alarm Systems and Thermostats

NOTE.—Only systems operating through a Central Station are approved.

10. CIRCUITS AND APPARATUS.—a. Must be arranged to transmit to central station the box number of the building in which a thermostat has operated, and unless floor number is transmitted with alarm, must automatically register the floor number on an annunciator located as required by the Inspection Department having jurisdiction.

b. Must be so arranged that not more than fifteen building equipments will be connected on a single circuit unless the circuit is mainly underground, in which case the number of equipments shall not exceed twenty-five (25), except by special permission of the Inspection Department having jurisdiction.

c. Transmitters, manual alarm boxes, testing boxes and annunciators must be of an approved make, and so located that a considerable jar cannot start their mechanism.

11. INSTALLATION OF THERMOSTATS.—For all Systems.—a. Must be placed throughout premises, including inside of all closets, in basements, lofts, elevator wells and under stairs. Special instructions must be obtained relative to placing them under large shelves, decks, benches, tables, overhead storage racks, and platforms, and inside small enclosures, such as drying and heating boxes, caul boxes, tenter and dry room enclosers, chutes and cupboards. No portion of the premises shall be excepted without written consent.

Special instructions must be obtained from the Inspection Department having jurisdiction as to the location of high test thermostats in boiler rooms, heating boxes, skylights, etc.

b. The distance from wall or partition not to exceed one-half the distance between thermostats in the same direction.

c. A line of thermostats to be run on each side of partition. This rule applies to both solid and slatted partitions.

d. Special instructions to be obtained from the Inspection Department having jurisdiction relative to location of thermostats under floors and roofs of panels or other unusual construction and for which provision is not hereinbefore made.

e. Must be supported in all cases independently of their attachment to the wires, except when cleats or knobs are within one foot of each side of thermostats.

f. Thermostats for hatch closers must be placed at the top of the elevator well or hoistway equipped, and on the ceiling below each floor opening in such numbers and so arranged in each case as may be required by the Inspection Department having jurisdiction.

FOR SYSTEMS EMPLOYING THERMOSTATS OPERATING AT A FIXED TEMPERATURE.—g. Under mill ceilings (smooth solid plank and timber construction, 6 to 12 feet bays) one line of thermostats should be placed in center of each bay and distance between the thermostats on each line not to exceed the following: 8 feet in 12 foot bays; 9 feet in 11 foot bays; 10 feet in 10 foot bays; 11 feet in 9 foot bays; 12 feet in 6 to 8 foot bays.

Measurements to be taken from center to center of timbers.

Special instructions should be asked where rule allows thermostat spacing to be over 10 feet, because special conditions may require the Inspection Department having jurisdiction to modify the rule.

h. Under joisted ceiling, open finished, distance between thermostats not to exceed 8 feet at right angles with joists or 10 feet parallel with joists.

Exception.—An exception may be made to this rule if the conditions warrant, viz., special permission may be given to install but one line of thermostats in bays 10 to 11½ feet wide from center to center of the timbers which support the joists. In all cases where such bays are over 11½ feet wide, two or more lines of thermostats should be installed in each bay as required by the rules for spacing. This does not apply where beams are flush with the joists, in which case thermostats may be spaced as called for in Rule *h*. Where permission is given, the thermostats should be placed closer together on a line so that in no case will the area covered by a single thermostat exceed 80 square feet. Also see Rule *d*.

i. Under smooth sheathed or plastered ceiling in bays 6 to 12 feet wide (measurement to be taken from center to center of timber, girder or other projection or support forming the bay) one line of thermostats to be placed in center of each bay, and distance between the thermostats on each line not to exceed the following: 8 feet in 12 foot bays; 9 feet in 11 foot bays;

10 feet in 6 to 10 foot bays. Bays in excess of 12 feet in width and less than 23 feet in width to contain at least two lines of thermostats; bays 23 feet in width or over to have lines therein not over 10 feet apart. In bays in excess of 12 feet in width, not more than 100 sq. ft. ceiling area to be allotted to any one thermostat.

j. Under a pitched roof sloping more steeply than 1 foot in 3, one line of thermostats to be located in peak of roof, and thermostats on either side to be spaced according to above requirements. Distance between thermostats to be measured on a line parallel with roof. Where the roof meets the floor line there should be a line of thermostats placed not over 3½ feet from where roof timbers meet floor.

NOTE.—Two lines of thermostats not more than 2½ feet distance each way from the peak of the roof, measured on a line with the roof, may be used in lieu of one line of thermostats located in peak of roof. Also see Section *d.*

k. Under open finish, joisted construction floors, decks and roofs, the thermostats should be "staggered" spaced so that the heads will be opposite a point half way between thermostats on adjacent lines, the end thermostats on alternate lines to be not more than two feet from wall or partition. Also see Section b.

NOTE.—This regulation does not except thermostats within a bay, whether on one, two or more lines. Special instruction to be obtained in each case as to whether staggered spacing shall be required under open joist construction, where the channel spaces between joists are positively blocked off within the territory of any two adjacent thermostats.

FOR SYSTEMS EMPLOYING THERMOSTATS OF ALL OTHER TYPES.—For thermostats not of the fixed temperature type special rules and requirements are established. These rules and requirements will be found in the List of Approved Fire Appliances, copies of which may be obtained from Inspection Departments, which should in all cases be consulted before these thermostats are installed.

12. MANUAL ALARMS.—Manual alarm boxes must be of an approved pattern, must be used for no other purposes, and must be located as required for Manual Fire Alarm Boxes. (See Rule 8, Section b.)

NOTE.—Manual boxes may be of the type such as is approved for Watchman's Time Recording Apparatus, Central Station Systems, if desired.

Class F—Automatic Journal Alarms

13. CIRCUITS AND CONNECTIONS.—a. Circuits must be so sub-divided that not more than 25 thermostats will be on any one circuit. There must be a finding switch for each boot in grain elevator equipments and elsewhere when called for by the Inspection Department having jurisdiction. All the finding switches in one circuit must be located in one box. The finding switches to be wired so that the cutting out of one group or boot will not cut off the current from any of the other groups in the same circuit and will show a broken wire when the test is made by the testing apparatus.

b. Connections must be made by running circuit wire without break from the binding posts. Where there is liability of mechanical injury, conductors must be encased in approved flexible, armored or iron conduits as the special needs of each case require. Armored or iron conduit must be securely fastened in place so as to prevent any strain on the conductors.

Where bearings are not fixed, such as tighteners, etc., a special approved flexible stranded conductor must be used.

c. Circuits must be all metallic and must normally test free from grounds. When open circuit systems are used they must be so arranged that a single break will not prevent an alarm being transmitted.

d. Thermostats must be on every bearing throughout grain elevators, exceptions only being made by consent of the Inspection Department having jurisdiction. Bearings must be drilled to the full depth of thermostat base where practicable and thermostats must be securely fastened in place.

e. Thermostats must be so arranged that they can readily be taken out of the bearings and disconnected without impairing the wiring or connections in any way, and their connections must be so arranged that journal boxes can be removed and replaced without breaking the wires.

f. Thermostats must be set to give an alarm at approximately 165 degrees Fahr., except by special consent of the Inspection Department having jurisdiction when thermostats may be set at not over 212 degrees.

g. An annunciator must be located near the testing apparatus with the indexes plainly marked to show the various circuits. It must be enclosed in a dust-proof case arranged so that the indexes can be reset from the outside of the case.

h. Independent relays must be used for each circuit; they must be enclosed in a dust-proof case and have spring knife edge contact points in addition to the ordinary relay contacts.

14. GONGS.—a. When vibrating gongs are used, all gongs must be of the regular vibrating pattern (not single stroke) and the system must be so arranged that the failure of any one gong to vibrate can in no way interfere with the proper action of any of the other gongs.

b. There must be one 8-inch gong placed over the annunciator in the engine room, which gong shall ring continuously in case of short circuit on system. This gong to be on a relay and separate set of batteries.

c. There must be no gongs in the journal alarm circuit when in normal condition. All gongs must ring from a relay.

d. There must be a 6-inch gong placed near each set of "finding switches," which shall ring continuously in case of short circuit on system. This gong to be on a relay and separate set of batteries.

e. Unless there is a spare man in engine room who can answer journal alarms, there must be an auxiliary system whereby the circuit number can be transmitted to each floor. Such a system to consist of an 8-inch vibrating gong located near center of each floor, gongs being on separate relay circuits. Approved transmitting and testing devices to be provided.

15. TESTING APPARATUS.—a. When all the wires of the system are not under constant battery test, there shall be a testing apparatus located in the engine room or where there is some employee on duty the entire time. Entire test to be made daily by operation of mechanism which, after test is completed, shall automatically leave the system in normal condition, or else give a continuous trouble alarm.

b. Testing apparatus shall record on dials continuity of all open circuits, shall ring all open circuit bells, and shall throw indexes of annunciators, a proper record not being obtained when any of the circuits or bells are out of order. Weakening of the batteries shall prevent the recording on dials before it has progressed sufficiently to impair the journal alarm.

16. GENERAL.—a. All journal alarm apparatus must be of an approved type.

b. Permanently fixed ladders must be provided wherever needed to make bearings readily accessible.

Class G—Watchmen's Time Recording Apparatus

17. CENTRAL STATION SYSTEMS.—a. Must not have more than forty boxes connected on a single circuit, nor shall more than five watchmen report on a single circuit.

b. Must be so arranged that fire signals which shall be distinct from watch signals can be sent from each station installed.

c. Watch boxes must be of an approved pattern, must be used for no other purpose, and must be located as required by the Inspection Department having jurisdiction.

When specific locations of watch boxes are not furnished by the Inspection Department having jurisdiction, they must be located so that the watchman in his rounds will cover plant, and, in addition, must conform with the following:

Must be located so that from any part of the plant equipped, not more than 200 feet will have to be traversed in order to reach a box.

Must, where buildings are more than one story in height, have a box on the first story, and at least one in alternate stories; i. e., 3d, 5th, 7th, etc. Where buildings have single floor area of 7,500 square feet, or over, there shall be at least one box on each floor.

Must, where any plant or building equipped is divided into sections, have the boxes in each section located to agree with above rules, account not being taken of boxes in any other section.

d. Complete and satisfactory tests of all transmitters must be made by installing companies monthly and results reported to the Inspection Department having jurisdiction.

18. LOCAL OR PRIVATE STATIONARY SYSTEMS.—a. The clock used must run for at least eight days without rewinding, and must be so encased that watch record dials cannot be seen without opening door, and so arranged that opening or closing of door will make a distinctive record on dial, this to be done by mechanical means.

b. Records must be made by perforating a paper dial and the puncturing device must be so arranged that it is not liable to stick in, adhere to, or tear the dial.

c. Magnetos must be used for the transmission of signals, must be of an approved type, and may be either portable or fixed at each station.

NOTE.—Where single station clocks are employed the recording apparatus may be operated by an approved mechanical device.

d. Stations must be placed as required by the Inspection Department having jurisdiction.

19. PORTABLE WATCH CLOCKS.—a. The clock used must run for at least 48 hours without rewinding, must be substantially mounted and strongly encased. It must be made so that the watch record dial cannot be seen without opening the case and so that it cannot be opened without puncturing or cutting the dial.

b. Records must be made by embossing or puncturing the dial and must be easily legible. Dial must be of sufficient size so that time at which the record is made can be accurately determined.

c. Stations must be located as required by the Inspection Department having jurisdiction, and fixed so they cannot be removed without giving evidence of the fact.

Keys must be made so that they are difficult to duplicate, and must be of a pattern susceptible of variations tending to reduce the probability that a set of keys fitted for one clock will operate other clocks.

Class H—Automatic Sprinkler Alarm and Supervisory Systems

20. CENTRAL STATION.—a. From the central office to the protected risk, there must be two (2) separate circuits, one for the water flow alarm, and the other for the supervision features. Manuals must not be installed on the supervision circuit unless of approved non-interfering pattern.

b. The central office must, at all times, be able to determine from the signal received, the particular feature of the sprinklered risk which is out of order and when it has been restored.

This may be accomplished by having separate transmitters for each feature of the service or distinctive signals from the same transmitter or by a combination of both methods.

21. DEVICES, CIRCUITS, ETC.—a. Must be so arranged that devices cannot easily be tampered with or removed without giving a signal in the central office.

b. All circuits and electrical apparatus must comply with the requirements stated under Class A. It is, however, strongly recommended that all interior circuits be entirely run in approved conduit piping, wire to be such as is required in damp places, under Rule 3, Section b, Class A.

c. All pipe connections to sprinkler system must be made in a workmanlike manner, equal in all respects to the regular standard required for sprinkler work.

d. Not more than twenty-five (25) sets of transmitters or not exceeding one hundred (100) break wheels must be connected on a single circuit.

22. TESTS.—Complete and satisfactory tests of all transmitters must be made by installing companies monthly and results reported to the Inspection Department having jurisdiction.

Supervision Details

23. GATE VALVES.—a. Connection, by means of approved devices, must be made to all gate or other stop valves, under control of the assured, in feed pipes to sprinklers, including all valves on tanks, fire pump, steam and discharge connections, city main connections, pump suction, post indicator valves, and where necessary, on small valves used in installation of the service. Devices to be so attached as not to interfere with the operation of the valve nor obstruct the view of indicator or access to stuffing boxes.

b. Attachments on all valves must give a signal between the first and second revolutions of the hand wheel, tending to move the valve from its proper position; or when valve is not controlled by hand wheel, signal must be given before the valve has moved 1/5 of the stem movement from its proper position.

Two separate and distinctive automatic signals will be required for the gate valve alarm, one signal to show that a valve has been removed from its normal position, and another distinctive and different signal to show that the valve has been returned to its normal position. The latter signal shall not be given until all valves have been returned to their normal position, or at least to the point where the first or trouble signal was given.

24. PRESSURE.—a. All tanks or their sources of pressure, including steam supply for fire pumps, also pressure on dry pipe system, must be provided with separate and independent attachments, unless otherwise specified by the Inspection Department having jurisdiction.

Pipe to which supervisory devices are connected, must be provided with a plugged test gauge connection and a stop and relief valve of satisfactory pattern; the whole to be so arranged that pressure on attachment and plugged connection can be released for testing purposes.

b. Pressure tank attachment must give a high and low pressure signal at ten (10) pounds below and thirty (30) pounds above the normal pressure.

Steam pressure attachment must give a low pressure signal at forty-five (45) pounds.

Attachment to dry pipe pressure system must give a high and low pressure signal at ten (10) pounds variation above or below normal pressure.

In special cases and for other pressure sources, specific instructions must be obtained from the Inspection Department having jurisdiction.

Two separate and distinctive automatic signals will be required for pressure alarm, one to show that the pressure has gone below or above the required amount and another distinctive and different signal to show that the normal pressure has been restored.

25. WATER LEVELS.—a. All pressure and surge tanks, gravity tanks, cisterns and reservoirs used as a supply for sprinkler systems, must be equipped with separate and independent attachments unless otherwise specified by Inspection Department having jurisdiction.

All devices used for this purpose must be designed to withstand corrosion and possible mechanical obstructions.

b. Must give a low water signal in all supplies, except pressure tanks, when water drops 12 inches below the required level. Pressure tank device must give a signal when water drops 4 inches below or rises 4 inches above the required level.

Two separate and distinctive automatic signals will be required for water alarm, one to show that water has changed from the required level, and another to show that the proper water level has been restored.

26. TEMPERATURE.—a. All gravity tanks, cisterns and reservoirs for sprinkler service in which water might freeze, must be equipped with suitable temperature indicator, located two feet below the required water level.

NOTE.—Where tanks, cisterns or reservoirs are located in houses in which water might freeze, Inspection Department having jurisdiction may require suitable temperature indicators for such houses.

b. The indicator must give a separate and distinctive signal when temperature falls below 40 degrees Fahr., or rises above 160 degrees Fahr., and another distinctive and different signal to show that water has been restored to the proper temperature.

27. FIRE PUMPS.—Where automatic fire pumps are used, a complete supervision shall be provided in each case, for which special instructions must be obtained.

28. WATER FLOW ALARM DETAILS.—a. At the base of each system riser, satisfactory and positive connections must be made by an approved device for indicating the flow of water in the sprinkler system, except that due to waste surges or variable pressure.

b. The device must indicate at the central station any leak or flow of water in the sprinkler system, equal to or greater than at the rate of ten (10) gallons per minute.

Trouble signal to be distinctive and different from the water flow signal.

c. Where any private local water flow alarm system is in use the supervisory water flow alarm must be so arranged that it shall not be dependent upon the operation of or interfered with by trouble on the local private alarm circuit.

29. MANUAL ALARMS.—Where a sprinklered risk is provided with either a central station water flow or a central station supervision alarm, or both, and has not an approved and properly maintained automatic fire alarm system, or watchman's central station time recording system, a manual fire alarm system installed in accordance with rules 8 and 9 must be provided.

30. SIGNALS AND REPORTS.—a. Arrangements must, if possible, be made by the operating company, by which they shall have access to premises under supervision, at all hours of the day and night. Where such arrangements cannot be made and it might become necessary to force an entrance to the building, a proper guard shall be placed over the building so long as required.

NOTE.—It will, of course, be understood that all arrangements, under the above paragraph, should be made with the owner of the property and must be subject to the approval of the Inspection Department having jurisdiction.

b. Arrangements must be made to furnish such reports of signals that may be received and in such form as may be required by the Inspection Department having jurisdiction.

31. DISPOSITION OF SIGNALS.—a. Upon receipt of signals referring to matters of purely equipment maintenance, the operating company must immediately send a runner to investigate and, if possible, see that the trouble is remedied at once.

They shall also notify the assured by telephone or by the quickest method available.

Written notice should be given the assured in all cases.

b. Upon receipt of signals showing flow of water in the system, the central office must notify the nearest insurance patrol and such other parties as the Inspection Department having jurisdiction may require.

They shall also dispatch a runner to the risk.

They shall also notify the assured by telephone or the quickest method available.

In addition to which, written notice should be given to the assured.

In all cases where notification is required to parties with whom private lines of communication have not been provided, the quickest available means of communication must be used.

c. If, at any time, a combination signal is received, which from its nature, is indicative of water flow on the premises equipped, such combination signal must be treated by the central office as a fire alarm.

All manual alarms are to be treated as fire alarms. Fire alarms received from sprinkler supervisory service must be transmitted to the city fire alarm office and patrol or such other places as required by the Inspection Department having jurisdiction, and should at all times be treated as still alarms.

Local Systems

32. ALARM DETAILS.—a. Must be arranged to give signals at points designated by the Inspection Department having jurisdiction.

These connections should be chosen from the following, choice being made in the order given.

1. Fire department house within 2,500 feet, having men and horses stationed therein.

NOTE.—In certain large cities the above connection alone will be required.

2. Fire department house within 2,500 feet, having "bunkers" and horses at night.
3. House of engineer or fireman of risk, when same is within 1,200 feet.
4. House of owner or superintendent of risk, when same is within 1,200 feet.
5. House of chief engineer or foreman of local fire department, when either is within 1,200 feet.
6. House of regular employee, other than those above mentioned, when same is within 1,200 feet.

When it is impossible to obtain any of the above, special instruction shall be obtained.

Connection to city or town fire alarm box is not allowable.

33. GONGS.—Must be not less than 6 inches in diameter. Where there is only one outside connection, gong shall be of vibrator pattern. Where there are two outside connections, gongs to be wired in series, a vibrator being placed in principal one, and a single stroke in the other.

34. TESTING OF LOCAL ELECTRIC ALARMS.—a. System to be tested daily by closing a circuit through the binding posts of the alarm valve. Test to be recorded by a device which shall make a series of punctures on a dial showing the vibration of the main gong. This device to be of single stroke pattern normally out of main circuit (i. e., in the test circuit connecting the binding posts) in series with and vibrated by main gong.

NOTE.—Inspection Department having jurisdiction should be consulted as to the necessity for installing the testing device, called for below.

b. Switches for cutting out alarms are prohibited.

The following requirements were submitted by the Committee on Signalling Systems at the 1915 meeting of the National Fire Protection Association. Up to the time this book went to press, they had not been finally approved by the Executive Committee nor adopted by the National Board of Fire Underwriters; they are given here as advisory to any one installing such a system, as many parts will not be changed in any modification which may be made by the committee, as they are standard practices in present good installations. The sections on which objections were raised are indicated herein.

Part II

Fire Alarm Signal Systems to Supplement Factory Fire Drills*

For use in factories, workshops and institutions where occupants are under discipline and control.

(These regulations are not considered generally acceptable for hotels, apartment houses or department stores.)

NOTE.—The portion of these rules relating to the design and construction of appliances is but a partial outline of requirements. A device which fulfills the conditions herein outlined, and no more, will not necessarily be acceptable. Samples of all appliances should be submitted to Underwriters' Laboratories, Inc., for examination and report before being introduced for use.

1. GENERAL.—(a) All devices and equipment constructed and installed under these rules and requirements shall be expressly approved for the purpose for which they are intended.

(b) Before acceptance is obtained for any equipment, the building owner must file with the inspection department having jurisdiction a general description of the apparatus he proposes to install together with such detailed information and drawings as are necessary for a complete understanding of the installation and operation of the system.

(c) Call systems now in use employing a signal code, or when installed in any factory building covered by these rules and requirements, must employ sounding devices of a distinctive type from those used in the fire alarm system.

(d) More than one class of fire alarm boxes shall not be installed generally throughout a factory building. Owners desiring to retain or secure the protection afforded by connection with the municipal fire department may combine such service with the equipment covered by these regulations.

EDITOR'S NOTE.—An objection having been made as to the wording of this sub-section, it will probably be changed in the final draft.

If the inspection department requires it, the building owner shall also furnish:

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* Reported by the Committee on Signalling Systems at the National Fire Protection meeting in 1915, but not yet finally adopted.

First.—Specifications, wiring diagrams and floor plans in duplicate showing the complete equipment including the source of electrical energy and the location of firm alarm boxes, signaling devices, exits, stairways, elevators and partitions, also the make and type of fire alarm equipment to be used and a schedule of signals indicating each floor. A copy of the approved plans and specifications will be returned as authority to proceed with the work.

Second.—A satisfactory guarantee as to the maintenance, operation and efficiency of the system.

2. WORKMANSHIP AND SUPPORTS.—(a) All work must be done in a workmanlike manner to the entire satisfaction of the inspection department having jurisdiction.

(b) All material must be rigidly secured in position, and when attached to masonry walls, shall be properly fastened by metal expansion shields or toggle bolts. Wooden plugs will not be acceptable. When deemed necessary to mount fire alarm apparatus upon a back board, such back board must not be less than seven eights of an inch in thickness, filled with a non-absorptive compound, with an air space of at least one quarter of an inch behind the back board for the free circulation of air.

3. TEST.—All systems must normally test free of grounds and, upon the completion of the fire alarm system, a satisfactory test of the entire equipment shall be made in the presence of and under the direction of the inspection department having jurisdiction.

4. ACCESSORIES.—Automatically operated circuit-breakers and engine stops for shutting down machinery in extremely noisy or hazardous premises may be required, connected with and made a part of the fire alarm system. In no case shall such circuit-breakers or engine stops be installed in such a manner as to cut off the power for lighting or to operate elevators.

5. DESCRIPTION OF SYSTEMS.—(a) A supervised system in the intent of these rules is one in which, when any part of the wiring system except open circuit portion of ringing circuit is grounded, broken or impaired, so as to prevent the normal operation of the system, a distinctive trouble signal is automatically registered at an approved central station of a supervising company.

(b) Boxes in all cases must be on closed circuits. Signaling devices may be on either open or closed circuits.

NOTE.—A switchboard for closed-circuit electro-mechanical bell systems is shown in diagram No. 3, and one for combined open and closed circuit systems (vibrating bells) is shown in diagram No. 4.

(c) For the transmission of an alarm on non-supervised systems a current flow must be employed of not less than 100 milli-amperes through an all closed circuit system, and 50 milli-amperes through circuits containing boxes only.

6. CIRCUITS.—(a) In all combined open and closed circuit systems, the open or signal portion of the system must be divided into at least two circuits in any one building.

NOTE.—For example, in a six-story building requiring two signaling devices on each floor, one on each floor must be on one circuit. When two or more signaling devices are located on any floor they must be divided approximately equally between the two circuits.

(b) If primary batteries are used to furnish the actuating energy, each open circuit must be operated by an independent battery of approved wet or semi-dry cells as indicated (K. K.) in wiring diagram No. 2.

In combined open and closed circuit systems employing storage batteries to furnish the actuating energy, the gong circuits and box circuits may be operated from the same battery.

(c) No circuit in which vibrating bells are connected in multiple shall contain more than eight bells.

No relay shall control more than sixteen vibrating bells or more than two open circuits. (See wiring diagram No. 1.)

(d) When an alarm has been sent in from any one of the alarm boxes, all the signaling devices on the various floors of the building shall automatically sound the number indicating the floor from which the alarm was sent, and shall repeat the signal at least four times.

(e) The fire alarm system must be used for no other than fire protective purposes. A milli-ammeter shall be provided in every closed circuit except in supervised systems.

(f) All signaling devices, alarm boxes, relay boxes and alarm box enclosing cases must be finished in red to distinguish them from other signaling apparatus.

7. TROUBLE SIGNALS.—(a) An enclosed trouble bell not less than 3 inches in diameter with magnets wound to not less than 10 ohms resistance, except in supervised systems, must be provided in connection with each closed circuit to ring continuously in case of weak batteries or an opening of the circuit. The bell, which shall be of an approved design of the vibrating type, must be placed in the engine room or other central point. At least four cells of open circuit battery of approved make and type must be provided for the bell. The bell and battery shall connect with the contact of a relay having the magnet windings in series with the closed circuit.

(b) Systems deriving energy from storage batteries may employ the reserve set of batteries to operate the trouble bell under conditions acceptable to the inspection department having jurisdiction. (See winding diagram No. 4.)

8. MAINTENANCE.—The system must be tested every morning before the hour of starting work in the building to insure the system and the batteries being in an operative condition. The test signal shall consist of two taps or blasts. Each alarm box must be operated at least once every month to prove that the mechanism is in perfect working order, in addition to necessary use of boxes in fire drills. All apparatus operated by springs, requiring winding shall be rewound after each alarm, and kept in normal condition for operation. A complete record shall be kept of the operation of each system, which shall be subject to examination by the inspection department having jurisdiction.

Fire Alarm Boxes

9. GENERAL.—There must be one or more fire alarm boxes on each floor of the building. Boxes shall be of an approved type and make and must be operated by a lever or by breaking glass. The box must be so designed that when once started the proper transmission of a complete set of signals cannot be interfered with by manipulation of its starting device.

EDITOR'S NOTE.—An objection was made to this last requirement.

Boxes should be so arranged that the alarm shall begin to sound not more than two seconds after the box has been started. Each box must be arranged to send a definite code of signals to indicate the floor or portion of same on which it is located. Not less than three taps or blasts shall be sounded at each revolution of the break wheel. The following suggestion is offered as a guide to assist in the arrangement of the signal code, but it is not to be considered as mandatory:—

Single Building of four floors and basement	1st floor	2-1
	2d floor	2-2
	3d floor	2-3
	4th floor	2-4
	Basement	2-5

10. DURATION OF SIGNALS.—(a) Whenever fire alarm boxes are made a part of the system in which electro-mechanical gongs are employed, break wheels should be so designed that the signal duration shall be not less than one-half second with silent interval of not less than one-half second between signals, except between numbers consisting of two or more digits and silent period between sounds.

(b) Boxes used in systems in which whistles, vibrating bells or horns are employed should be so designed that the signal duration shall be not less than one second, nor more than one and one-half seconds with silent intervals of three quarters of a second to one second, except between numbers consisting of two or more digits and between sounds.

11. DESIGN AND CONSTRUCTION.—(a) There must be a metal case completely enclosing the movement and made dust-proof as far as possible by the use of gaskets or other suitable means. The metal case shall be drilled and tapped to receive standard conduit at top and bottom.

(b) All parts of the mechanism must be of the best grade and workmanship. Contact points operated by a break wheel, and contact points on testing devices shall be of commercially pure platinum or silver, and shall be of the scraping type. All contact points must be secured in a substantial manner to phosphor bronze springs, and all current-carrying parts shall be insulated from the mechanism of the box. The break wheel shall be made of suitable non-conducting material, or insulated from the carrying shaft, and shall not be employed in any manner as an electrical conductor.

Provision must be made for a silent test of the box mechanism without operating the signaling devices. The testing device must be of a design which will prevent any person, except those in authority, from operating same. Testing devices must be so designed as to prevent possibility of box being left inoperative.

(c) Lever boxes must be designed to wind automatically when the lever is pulled for an alarm.

Lever box cases must be fitted with a door which can readily be opened, so constructed as to protect the pull lever against accidental injury and on which a handle is rigidly secured. The wording "In case of Fire open Door and pull down Lever as Far as it will go," or equivalent instructions must appear on the door. If used in exposed places, the box shall be enclosed in a suitable weatherproof outer shell.

Approved types of break-glass boxes will be acceptable with no additional protection except where made necessary by weather conditions, and every break-glass type fire alarm box shall be provided with suitable hammer on chain which shall be attached to or near the box, so that the glass can readily be broken. All break-glass boxes shall have lettered on the fronts the words "Fire Alarm—In case of fire break glass." All boxes requiring glass replacements shall be so arranged that replacement cannot be made until the mechanism is reset for another alarm.

Signaling Devices

12. GENERAL.—Signaling devices may consist of bells of approved type or other devices acceptable to the inspection department having jurisdiction. There shall be installed on each floor of the building one or more alarm devices, sufficient in number and efficiency to be plainly heard throughout the floor above the noise of the machinery and other sounds. Where floors are divided by fire walls, each section may be deemed a separate floor for the purpose of these requirements.

Systems consisting of several types of sounding apparatus should be avoided.

13. DESIGN AND CONSTRUCTION.—(a) All signaling devices must be of an

approved type, and the movement enclosed in a substantially dust-proof metal casing insulated from all current-carrying parts. Where conditions require it, moisture-proof casings must be provided. Signaling devices shall be placed with their lowest parts about eight feet from the floor. Wherever there is danger of mechanical injury, the entire device shall be enclosed in a protecting case made of approved wire netting or perforated metal.

(b) Gongs must be made of a high grade of cast bell metal, or other approved material, and shall be, except by special permission, not less than 8 inches in diameter.

(c) Adjustments must be of such a character that they can be securely locked in an approved manner.

(d) Contact points must be ample in area, not only to take care of current used in operation, but to insure long life, and shall be of commercially pure silver, platinum, carbon, or other approved material.

(e) Hammer rods must be protected against mechanical injury or derangement by the use of a guard or other suitable means.

14. HORNS AND WHISTLES.—When conditions in a factory building make the use of fire alarm horns necessary, they may be required and shall be installed in a manner acceptable to the inspection department having jurisdiction. A difference of potential of not less than 30 volts, nor in excess of 50 volts shall be provided on horn circuits. Horn field and armature windings shall be of a resistance value suitable for the voltage employed.

Electrically controlled whistles may be required as auxiliary equipment, and shall be installed in a manner acceptable to the inspection department having jurisdiction.

Relays

15. DESIGN AND INSTALLATION.—(a) All relay must be mounted in a vertical position, magnets up, and be enclosed in an approved metal case under lock and key and located where there is no danger of sparking contacts igniting inflammable gases or flyings.

(b) Relays must be mounted where they will be least affected by vibration in building, and in no case shall they be mounted on the same backboard with sounding apparatus, or so that they will be affected by the vibration caused by such sounding apparatus, and shall be plainly marked with the maximum and minimum operating current values to which such relays will safely respond.

Wiring

16. WIRING.—(a) All conductors must be run in approved metallic conduits or armored cable installed as follows: Conduits and armored cables, when not terminated in drilled and tapped fittings, shall be rigidly secured to all fittings by approved locknuts and bushing. Conduits shall be not less than ½-inch internal diameter where not more than four conductors are used, and where a greater number of conductors is used, the internal diameter of the conduit shall be at least 3/16 of an inch larger than the outside diameter of the bunched wire it is to accommodate.

Fire alarm conduits shall not contain any foreign wires whatever. The conduit system shall be permanently and effectually grounded.

(b) All wires must be rubber covered, and braided National Electrical Code standard. Wiring in all systems shall be installed after the manner prescribed under National Electrical Code rules as applying to conduit and armored cable installation.

(c) Except for supervised systems, no conductor of less than No. 14 B. & S. gauge, not having a rubber insulation wall of less than 3/64 of an inch thick will be approved.

For supervised systems, wires must have an approved covering consisting, except as noted below, of a rubber insulation at least 1/32 inch in thickness and a substantial braid.

Multiple conductor cables consisting of three or more wires may be not less than No. 16 B. & S. gauge, and have an approved rubber insulation not less than 1/32 of an inch in thickness.

(d) Where wires pass from one building to another, they must be enclosed in rigid conduit underground between buildings wherever possible, and when so installed must be lead encased.

(e) Wires between buildings when not run in conduit must be at least equivalent in conductivity and tensile strength to No. 12 B. & S. copper for box and signaling circuits. They must be supported at least every 75 feet on approved glass insulators and brackets. As far as possible they should be run under rather than over electric light or power wires.

PROPERTIES OF WIRE

Size, B. & S. Gage	Area, Square Inches	Area, Circular Miles	Resistance, Ohms per 1000 feet	Weight per Mile, Lbs.	Breaking Strength, Lbs.	Tensile Strength, Lbs. per Sq. In.
Copper Wire, Hard-drawn						
7	.0163	20820	0.5085	332.	990	60000
8	.0130	16510	0.6413	264.	788	60500
9	.0103	13090	0.8087	209.	630	61100
10	.0082	10380	1.0197	166.	506	61600
12	.0051	6530	1.6218	104.	318	62400
14	.0032	4107	2.5780	65.7	202	63100
16	.00203	2583	4.0996	41.3	140	68000
Aluminum Wire, Average Grade A75						
7	.0163	20820	0.86	100.21	586	36000
8	.0130	16510	1.105	79.46	481	37000
9	.0103	13090	1.367	62.99	402	39000
10	.0082	10380	1.724	48.71	328	40000
12	.0051	6530	2.741	31.43	214	42000
14	.0032	4107	4.467	19.76	141	44000
B. W. G.	**Iron Wire, E. B. B.**					
8	.0213	27225	2.36	378.	1134	18800
9	.0172	21904	2.93	305.	915	18800
10	.0141	17956	3.57	250.	750	18800
11	.0113	14400	4.45	200.	600	18800
12	.0094	11881	5.39	165.	495	18900
14	.0054	6889	9.29	96.	288	18800
16	.0033	4225	15.16	59.	177	18700

DOUBLE GALVANIZED TELEGRAPH WIRE

Size B. W. G.	Diam., Inches	Weight, Lbs. per Mile	Breaking Strength, Lbs.			Resistance Ohms per Mile		
			E. B. B.	B. B.	Steel	E. B. B.	B. B.	Steel
4	.238	811	2433	2676	3000	5.98	7.15	8.32
6	.203	590	1770	1947	2183	8.14	9.83	11.44
8	.165	390	1170	1287	1443	12.43	14.87	17.31
9	.148	314	942	1036	1162	15.44	18.47	21.62
10	.134	258	774	851	955	18.80	22.48	26.16
11	.120	206	618	680	762	23.54	28.15	32.76
12	.109	170	510	561	629	28.53	34.12	39.70
14	.083	99	297	327	366	49.00	58.58	68.18

COPPER AND COPPER-CLAD WIRES

Comparison of Hard Drawn Copper and Forty Per Cent Copper Clad Steel

B. & S. Gage	Weight, Lbs. per Mile		Breaking Strength, Lbs.		Resistance, Ohms per Mile	
	Copper	Copper Clad	Copper	Copper Clad	Copper	Copper Clad
6	419	390	1237	1800	2.18	5.45
7	332	309	980	1450	2.76	6.90
8	264	245	778	1200	3.49	8.73
9	209	194	617	975	4.39	10.97
10	166	154	489	800	5.49	13.72
11	131	122	388	650	6.90	17.25
12	104	97	307	510	8.70	21.75
13	83	77	244	410	10.01	27.57
14	66	61	193	330	13.44	34.85
15	52	49	153	250	17.57	43.92
16	41	38	133	200	21.95	54.97
18	26	24	77	130	35.71	89.27

Weights of Copper and Copper Clad Weather-proof Wire, pounds per Mile

B. & S. Gage	Diam., Inches	Double Braid		Triple Braid	
		Copper	Copper Clad	Copper	Copper Clad
3	.2294	993	918	1059	991
4	.2043	800	748	866	818
5	.1819	644	608	736	673
6	.1620	528	499	591	560
8	.1285	349	330	402	376
9	.1144	284	268	330	310
10	.1019	250	229	285	268
12	.0808	158	151	185	178
14	.0641	106	102	132	127

Three per cent variation allowed.

Sources of Electrical Energy

The following sources of energy may be employed:—

1. Storage batteries in duplicate.

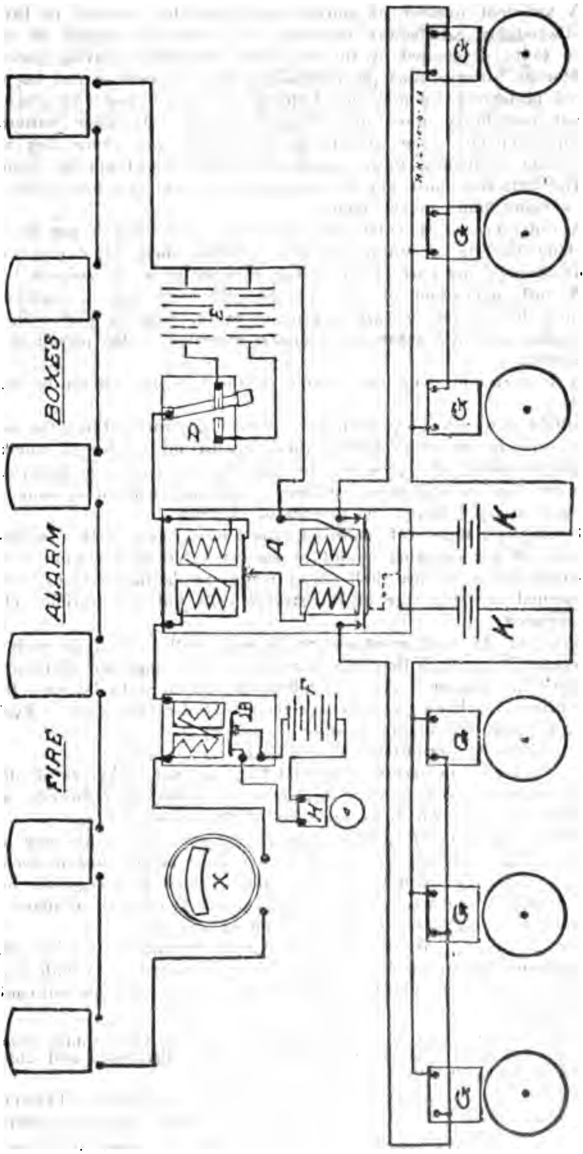
2. Electric Light or Power system (Public Service or isolated plant), supplemented by storage batteries controlled by automatic throw over device.

NOTE.—By special permission of the inspection department having jurisdiction the storage batteries may be omitted.

3. Primary batteries in duplicate.

17. STORAGE BATTERIES.—(a) Storage batteries may be employed if under competent supervision and equipped with reliable charging and controlling devices.

(b) Storage batteries must be of approved make and type. Each set must be capable of maintaining the system efficiently for seven days without recharging, and must be of not less than 24-ampere-hour capacity.



Wiring Diagram No. 1.

(c) A sufficient number of storage cells must be provided in battery to secure thoroughly satisfactory operation, the required number in each installation to be designated by the inspection department having jurisdiction.

(d) Storage batteries must be installed in an approved manner in properly ventilated protecting cabinets and, wherever possible, must be placed in a room not containing other fire alarm apparatus. If these batteries are placed in a separate room with proper ventilation and where they will not be subject to mechanical injury, protecting cabinets will not be required.

(e) The batteries must not be disconnected from the fire alarm system during working hours in the factory.

(f) A difference of potential of more than 60 volts will not be allowed on working circuits of storage battery systems when the current flow at any time through any part of the system is more than one ampere.

(g) A full description of the operation of each system, together with instructions for its proper care and maintenance, must be posted in a conspicuous place and in a substantial manner, accessible to the person in charge of the system.

(h) It is preferable that the voltage of the charging circuit be not over 250 volts.

(i) Suitable provision to be made on a switchboard for charging the batteries, with approved means of protecting them against injury due to interruption of charging current; also provision for shifting the respective batteries from charging to working and from working to charging without opening any of the working circuits during the process of shifting.

Fixed resistance units (of approved type and design) to be provided, one in each leg of the charging circuit of such a value as operating conditions may warrant but in no case shall the charging rate be in excess of two thirds of the normal charging rate of the storage cells unless a variable charging rate is required.

One third of the total resistance to be used shall be fixed in each leg of the charging circuit, and the balance provided with approved shifting device for varying the charging rate; the minimum resistance to be such that the batteries cannot be charged in excess of their normal charging rate. Resistance in any case must not unduly heat.

Lamps will not be permitted for resistance.

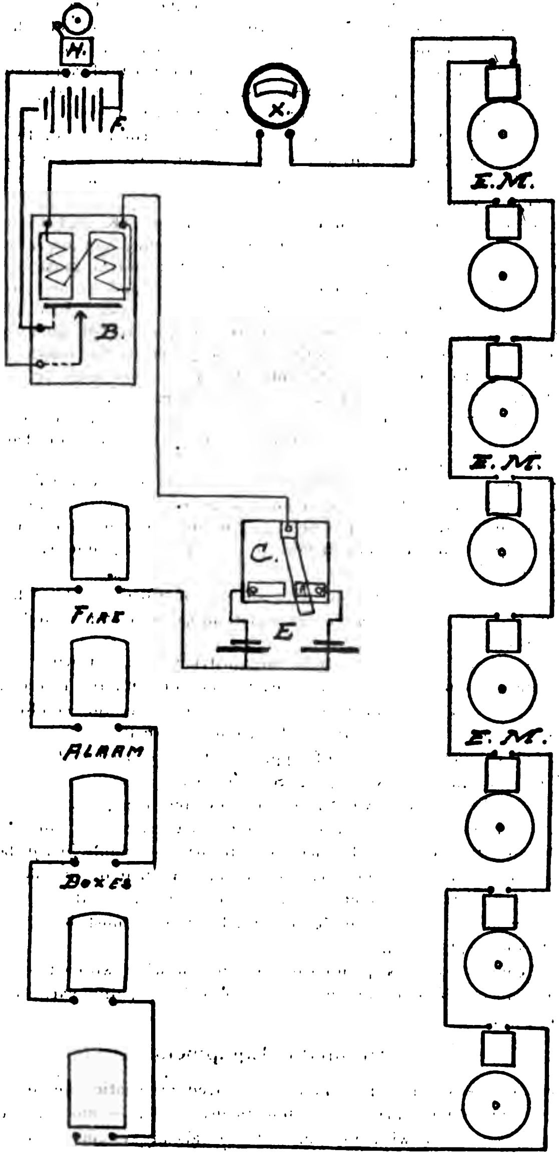
Fuses 50 per cent in excess of normal load and not in excess of allowable carrying capacities of wire must be provided at battery terminals, and on all working circuits. All fuses must be of the enclosed type.

(j) Motor generators of suitable capacity and standard design may be used for charging storage batteries, and when used must be installed in accordance with the National Electrical Code rules, and a proper field regulator must be provided in addition to regular switchboard equipment referred to above, except that resistance in charging circuits will not be required.

(k) For alternating current when alternating current is used for charging storage batteries, approved motor generators or rectifying sets with necessary transformer must be provided, together with regular switchboard equipment above specified.

NOTE.—Electrolytic rectifiers will only be allowed when under competent supervision, and when employed a reserve set of electrodes and charge of salts must be kept on hand.

18. **ELECTRIC LIGHT AND POWER (PUBLIC SERVICE OR ISOLATED PLANT), SUPPLEMENTED BY STORAGE BATTERIES.**—Systems of this character are special, and complete details of installation must be submitted for approval in each case to the inspection department having jurisdiction, which may, by special permission, authorize the omission of the supplementary storage batteries.



Wiring Diagram No. 2.

19. PRIMARY BATTERIES.—(a) The battery on the closed circuit must be in duplicate and be provided with an approved single pole, double throw, knife blade switch, so arranged that when changing from one set of batteries to another the circuit cannot be broken, and shall consist of approved standard closed circuit cells of not less than 300-amperes-hours capacity. Approved heat-resisting glass jars are preferred, but at least one glass jar shall be used in each series for the purpose of observing the condition of the elements. The working voltage of approved closed circuit cells is .65 volts per cell. Dry cells shall not be used as actuating energy in any closed circuit, except in supervised systems.

(b) The battery on the open circuits as indicated (K. K.) in wiring diagram No. 1, shall consist of high grade open circuit, wet or semi-dry cells of approved type and make. A reserve set of batteries must be provided and chemicals furnished with them in a dry state, and as any set becomes exhausted, they shall immediately be prepared for service. Multiples of dry cells in approved containers may be substituted for wet or semi-dry cells in each open or bell circuit under conditions acceptable to the inspection department having jurisdiction. A sufficient number of cells must be provided in each battery to secure thoroughly satisfactory operation.

(c) The current flow from any primary battery shall not exceed 2 amperes.

(d) All batteries must be coupled together by means of battery connectors of approved type.

20. CABINETS FOR PRIMARY BATTERIES.—(a) All primary batteries must be placed in substantial well-fitted cabinets, elevated not less than six inches and not more than six feet above the floor and located in a clean, dry place where the temperature will not fall below 40 degrees Fahr. nor rise above 100 degrees Fahr.

(b) Cabinets must be provided with shelves of wood not less than ⅞-inch in thickness or of other approved material, properly fastened and secured to prevent sagging.

Supports for dry batteries must be so constructed that it will be impossible for the cells to come in contact with each other or with the metal enclosures.

Main battery cabinets must be so constructed that the condition of the elements may be observed without disturbing the cells.

(c) Metal cabinets must be of approved type, constructed of sheet iron or steel of not less than No. 14 U. S. metal gauge.

Doors must be provided with lock and key and kept closed.

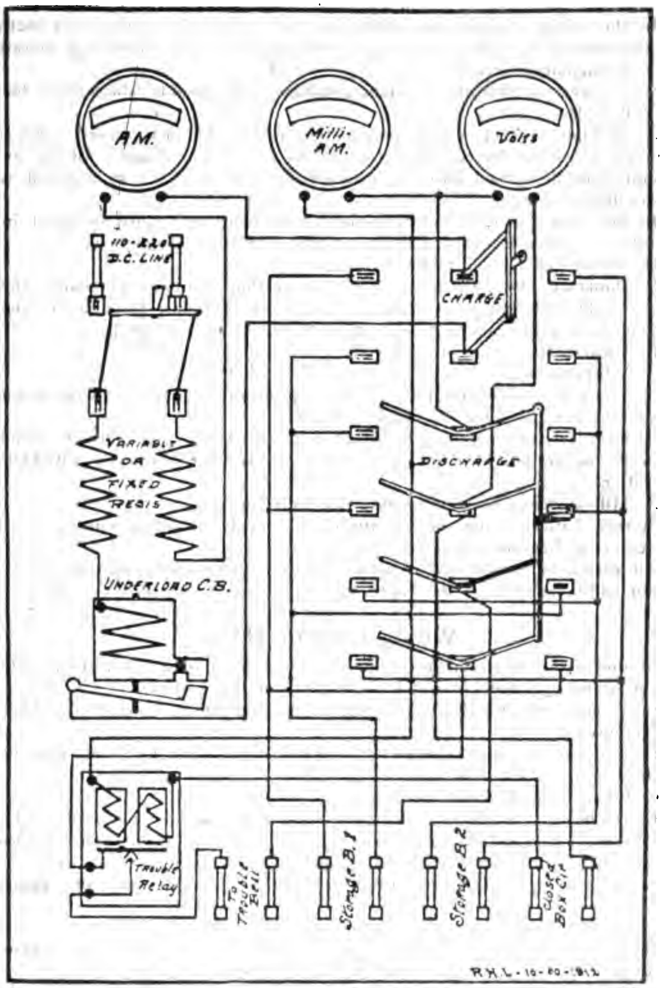
The interior and the exterior of metal cabinets must be painted with two coats of asphaltum compound, each coat to be thoroughly dried before the next is applied. Baked enamel will be accepted in lieu of the above.

(d) Wooden battery cabinets must be constructed of the best grade of kiln dried wood not less than ⅞-inch thick. Doors must be provided with a padlock and kept closed.

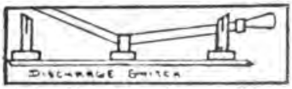
Wooden cabinets must be painted on the interior with two coats of asphaltum compound and on the exterior with two coats of lead paint, varnish or asphaltum compound.

Automatic Equipment

21. SPECIAL PERMISSION REQUIRED.—Approved automatic fire alarm devices and thermostat systems arranged automatically to set in motion transmitting devices in connection with the manual fire alarm systems covered by the foregoing rules, may be allowed by special permission of the inspection department having jurisdiction.



Closed Circuit D. C. Control Board for Electric Mechanical Gongs.



Wiring Diagram No. 3.

Wiring Diagram No. 1

In this wiring diagram an outline has been given of a satisfactory method of installing a combined open and closed circuit system employing vibrating bells as signaling devices.

It is suggested that the resistance, voltage and current values given below be followed:—

A. Multiple contact master combination relay. Magnets shown connected into the closed or box circuit be wound to 25 ohms resistance. Relay to be mounted in a vertical position, magnets up, and enclosed in a metal case under lock and key.

B. Fire alarm trouble relay wound to 25 ohms resistance mounted in a metal case under lock and key, in a vertical position, magnets up.

D. Single pole double throw switch.

E. Duplicate closed circuit batteries consisting of 300-ampere-hour closed circuit cells sufficient in number to cause a current flow through the closed circuit of 50 milli-amperes based on an E. M. F. of .65 volt per cell.

F. Local battery of approved cells.

G. Vibrating bells.

H. Covered trouble bell not less than 3 inches in diameter, with magnets wound to not less than 10 ohms resistance.

K. Open circuit batteries consisting of approved cells. A sufficient number of cells to be provided in each battery to secure thoroughly satisfactory operation.

X. Milli-ammeter scale to read 0-100 milli-amperes.

Storage batteries may be substituted to supply actuating energy in this system (see diagram No. 4).

All wiring to be installed in rigid iron conduit or steel armored cable.

For additional details, see specifications.

Wiring Diagram No. 2

In this wiring diagram an outline has been given of a satisfactory method of installing a closed circuit electro-mechanical bell system.

It is suggested that the resistances, voltage and current values given below be followed.

B. Fire alarm relay mounted in a metal case under lock and key, in a vertical position, magnets up.

C. Single pole double throw switch.

E. Duplicate batteries consisting of 300-ampere-hours approved closed circuit cells sufficient in number to cause a current flow through the closed circuits of 100 milli-amperes based on an E. M. F. of .65 volt per cell.

Storage batteries may be substituted. (See specifications and diagram No. 3.)

F. Local battery of approved cells.

H. Covered trouble bell not less than 3 inches in diameter of approved type with magnets wound to not less than 10 ohms resistance.

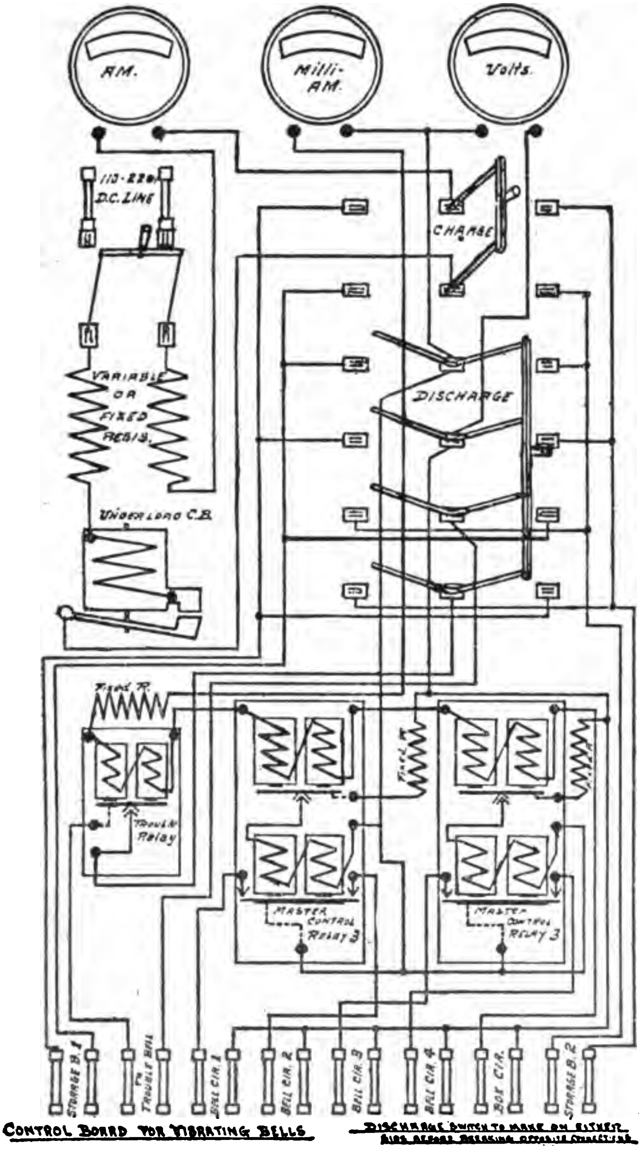
E, M. Electric-mechanical gongs of approved single stroke type wound to not less than 30 ohms resistance.

X. Milli-ammeter scale to read 0-200 milli-amperes.

All wiring to be installed in rigid iron conduit or steel armored cable.

For additional details, see specificatons.

Watchman Time Recording Apparatus.—As an auxiliary to any signalling system, and a necessity where the signalling system is not automatic, such as a thermostat or sprinkler flow system, is



Wiring Diagram No. 4.

the service of a watchman. Not only is he of value in discovering fires, but also in preventing them, by turning off carelessly left gas or electric current on heaters, etc., and cleaning up rubbish which may ignite spontaneously.

To be of full value, assurance of his being on duty is a requisite, and as a general rule underwriters insist that he be checked up in his rounds by being made to punch a clock at stated times, or to send in a signal to a central station. These clocks or signal stations must be of such a design that they can not be tampered with, or the records changed. Practically the only assurance that such apparatus is properly safeguarded from tampering is by insisting on a system or a time recorder labeled by the Underwriters' Laboratories, who have listed to date one make of watchman's call and fire alarm box for use in connection with standard normally-closed circuit central station watchman's time recording apparatus, eleven manufacturers of portable time recorders and key boxes, and fourteen manufacturers of stationary recorders.

In any watch service it is strongly recommended that the old idea of employing superannuated men for watchmen be discarded; the service, although probably not showing immediate returns on the profit side of the books, such as other workmen's services about a plant do is of really such great value that only men in their prime should be employed, and a sufficient wage paid to get good, sober, efficient men, who can be properly trained. With such a watchman a plant is far better protected than the average.

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THE DESIRABILITY OF HIGH PRESSURE FIRE SYSTEMS*

The immense aggregations of values in the buildings and their contents in the business districts of metropolitan cities, and the possibility of conflagrations, with their tremendous losses and disastrous effects on business and civic growth, are striking arguments in favor of providing the most effective known means of preventing such catastrophes.

Although there is a tendency at the present time to replace old buildings with others of fireproof construction, such being required for certain heights and areas by city building laws, the number of buildings of such construction is comparatively small. The probability of serious fires originating in these buildings is small, but with the general lack of protection against exposure across narrow streets and passageways, they would not withstand the attack of a fire from adjacent and neighboring buildings of other classes.

Although a sprinkler equipment will effectively control a fire originating within the building in which it is installed, it does not make that building a conflagration barrier; and since most of the equipments are connected to the system of street mains, the efficiency of the supply to all these equipments may be seriously impaired, and the ability to resist exposure fires lessened, by the breaking of service connections to one or more buildings in which a fire has got beyond control.

Structural conditions, occupancies and other features tend to produce a high conflagration hazard particularly in sections which consist of large-area blocks, with crowded and poorly accessible interiors, no floor-opening or window protection where especially needed, and numerous large floor areas, affording opportunity for the rapid spread of fire.

It is therefore evident that, taken as a whole, the chances for sweeping fires in large cities are considerable, even though the fire department is efficient and well maintained. All that is required, under existing weak building conditions, is the right combination of circumstances to make a fire too large for the department to handle. This combination of circumstances nearly occurred in Boston on August 9, 1910, when two serious simultaneous fires, as described hereinafter, called out practically the entire Boston fire department and much apparatus from the surrounding cities. Had either of these fires been a little larger, or had a third fire occurred almost anywhere in the city, for example, in any of the number of congested frame residential sections, which are becoming increasingly hazardous, a bad conflagration would undoubtedly have occurred.

It is in realization of the possibilities of such conditions that the larger American cities are making every effort to install the most powerful fire-fighting facilities available. Systems of high pressure water mains used exclusively for fire protection are installed in New York (one in Manhattan, one in Brooklyn and one at Coney Island), Philadelphia, Toronto, Ont., Winnipeg, Man., Cleveland, Detroit, Buffalo, Oakland, San Francisco and Baltimore. Portland, Ore., Toledo, Ohio, Boston and Cincinnati have started them.

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*Abstracted from a pamphlet issued by the National Board of Fire Underwriters.

Philadelphia has used its system for nearly 12 years, and Manhattan and Brooklyn about 7 years; the experience in these cities proves the feasibility of separate high pressure fire systems and their superiority over fire engines, especially for large fires which tend to assume conflagration proportions.

The Manhattan system illustrates the possibilities and advantages of such equipments. The main features are a gridironed system of underground pipes, 12 to 24 inches in diameter, to which is connected two pumping stations taking water from the city mains and delivering into the high pressure system at pressures of 125 to 300 pounds. Each station is equipped with 6 centrifugal pumps, driven by direct connected induction motors. Each pump was guaranteed to deliver 3,000 gallons of water per minute at 300 pounds pressure, and at the acceptance tests did deliver an average of 3,600 gallons per minute, a total of 43,000 gallons for both stations. The delivery is proportionately greater at lower pressures, and reaches a total of about 62,000 gallons per minute at 200 pounds pressure. Fresh water is used, as it causes less damage to stock than salt water, and also because it has less effect on the pipe of the system; however, the stations are located close to tide water and all necessary connections are made for the use of salt water in emergency. The precautions taken to insure the integrity of the pumping stations and the reliability of operation include: Pumping stations of fireproof construction throughout, protected against exposure fires and located outside the conflagration zone; power for operating the pumps supplied from 5 different power stations of the New York Edison Company, with duplicate sets of underground cables to each pumping station; duplicate mains from the pumping stations to the gridiron system, and automatic relief and pressure-regulating valves at each station. Pressure is not kept up at all times; when a fire alarm comes in from the district covered by the system the pumps are started and pressure raised to 125 pounds. This takes less than one minute, so that the water is always ready before the fire department can lay a line of hose and connect to a hydrant.

Large post hydrants, to which 4 or 5 lines of hose may be attached, are the only connections through which water can be drawn from the system, and the possibility is avoided of connections inside buildings breaking and bleeding the system. Each hydrant is capable of supplying at high pressure as much water as 5 ordinary fire engines of the first size.

The tendency in all modern fire departments is to use large, penetrating streams, as these alone are effective on a fire well under way in the ordinary, large-area building filled with combustible stock. Each large stream requires, under the most favorable circumstances, one first size or larger engine or two smaller ones, working up to full capacity, while one hydrant on the high pressure system can supply 4 or 5 such streams.

A signalling system is provided, by means of which the officers in charge at a fire can communicate with the pumping stations from any location in the district covered. More pressure can be ordered at any time and is immediately available. As many of the pumps are operated as are necessary to maintain the desired pressure and this pressure can be sustained for any length of time. Mr. I. M. de Varona, Chief Engineer of the Department of Water Supply, Gas and Electricity, New York, reports as follows on January 26, 1909:

"The high pressure fire system in New York, which was put officially into service on July 6, 1908, has been successfully operated since that date at one hundred and fifteen fires, but it had its crucial test, and one to which it will not probably be subjected again in years, on the 7th, 8th and 9th of

January, 1909, when it was brought into service for five simultaneous fires, three of them of much more than the usual extent and activity, one particularly so.

"These fires occurred at Hudson and Franklin streets, Hester street and the Bowery, Houston street and Broadway, Sixth avenue and 17th street, and Houston street and the Bowery. The situation became so dangerous that every engine south of 37th street—i. e., forty engines—was summoned, as well as a force consisting of twelve battalion chiefs and more than 600 men, but there was no need to use a single one of the fire engines. The fire at Franklin and Hudson streets was particularly severe, and described by Chief Croker as a '3-9' fire. But even in that case, the extraordinarily effective work of the high pressure fire streams prevented the spread of the flames beyond the building in which the fire originated, and successfully extinguished it—a result which the Fire Department Chief declared could never have been accomplished with the old system. The result was the same at the four other fires.

"The area of buildings, number of alarms and time of service were as follows:

"At Hudson and Franklin streets, where the largest fire occurred, the area of the building affected was 13,400 square feet. For this fire, four alarms were received, the first at 7:22 P. M., on January 7th, and the service was shut down at 10:34 A. M., on January 9th.

"At Hester street and Bowery, the area of building affected was 3,600 square feet. Three alarms were received, the first at 7:52 P. M., January 7th.

"As the violence of the fire increased, additional pumps were brought into service, so that at one time four pumps and motors were in commission at the Oliver and South Street Station and three pumps at the Gansevoort and West Street Station, delivering 33,500 gallons per minute against an average pressure of 225 pounds at the pumps and 205 pounds at the hydrants."

Chief Croker of the New York Fire Department is of the opinion that several fires have been checked by the use of the high pressure system which would otherwise have assumed disastrous proportions. This is due to the ability of the department to put in operation a large number of powerful streams in much less time than could be done with fire engines and without the confusion attendant upon their use.

The other high pressure systems in operation and in course of construction involve the same general features, differing, according to local conditions, in capacity, in type of pumps and in motive power; in addition to centrifugal pumps and electric motors, reciprocating pumps and steam, gas and oil engines are successfully used. The Buffalo, Detroit and Milwaukee systems are not provided with pumping stations, fire-boats being used for this purpose; this has such serious disadvantages that most of these cities are contemplating the erection of a pumping station when money is available.

In the area covered by a high pressure system, it is possible to dispense with a number of fire engines and substitute large hose wagons; in Manhattan, eight engines have been thus replaced. The number of pieces of apparatus necessary is reduced and the engines replaced can be removed to districts where they may be needed. Not much additional apparatus would have to be provided, as the hose wagons and hose with which the department is now equipped could be used in connection with the system. An engine company of 13 or 14 men equipped with a large hose wagon can lay 3 or 4 lines and handle as much water as could be delivered by twice that number of engines. This means that 2 of the men required to operate and drive an engine would not be needed for this purpose and would be available for hose duty in each company converted from an engine to a high pressure hose company. Two of the high pressure wagons may be put in the quarters which now house a single engine company, thus the protection of the district covered from one station can be greatly increased.

Another great advantage of such a system, as brought out in the report quoted above, is that the high pressure companies responding on first alarms can handle fires which, under the present system, require second or third alarms, being able to quickly put powerful streams in operation on the fire and also to handle in the early stages as many streams as can be obtained from the engines responding on third alarms. The average time between the receipt of a first alarm and the sending of a second alarm for the same fire is 6 minutes in Boston, and it will take an average of 5 minutes more before the second alarm companies are at work, under the most favorable conditions. Thus, with the high pressure system there is a saving of time at the most vital stage of a fire; this saving will be at least as much as the time between the first and second alarms, and for fires which would now require a third alarm the saving is even more.

But of all points justifying the installation of a special high pressure system, probably the most important is the unprotected condition of the congested value district, if fire engines are depended upon, during the progress of a seriosu fire of several hours' duration in another part of the city. This was exemplified in Boston on August 9, 1910: An alarm was received at 6:17 P. M. from Box 58 (corner of Dover and Albany streets) for a fire which started in the lumber yard of Blacker & Shepard Lumber Company, at 350 Albany street. The fire had attacked adjoining property when the first apparatus arrived, and in a few minutes crossed Albany street into a frame tenement block, the fire department repair shop and a wood-working factory. Boxes 56 and 112 were also pulled for this fire, and alarms from Box 58 were sent as follows: Second at 6:23, third at 6:27, fifth at 6:28, and sixth or general at 6:30 P. M. These alarms called to the fire 38 engines, 2 fire-boats, 16 ladder companies, 5 chemical engines and 3 water towers. This left, for the immediate protection of the city, 7 engines, 11 ladder and 8 chemical companies. At 6:28 P. M., while the fire was still spreading, the fire alarm office began calling for assistance from the surrounding towns and cities; 17 engine and hose, 2 hose and a ladder company were sent and began to arrive in about 30 minutes. The first of this apparatus, 9 engines in all, went directly to the fire. Three engines and one ladder company went into quarters to cover districts without protection.

At 7:50 P. M., while the fire on Albany street was still burning fiercely and not as yet well under control, an alarm was received from Box 44 for a fire in a 5-story granite building, 55-59 High street, occupied by the H. W. Johns-Manville Company. Four engine, 4 ladder and 3 chemical companies of the Boston department, which were in quarters, responded and out-of-town apparatus on the way to the Albany street fire began to arrive soon after. This fire was very stubborn and at 8:43 a second alarm was sent from Box 44. At that time the only apparatus in fire stations in the City of Boston consisted of a ladder, a chemical and two engine companies in East Boston, a ladder company and a chemical engine in Charlestown, an engine, a chemical and a ladder company in Brighton, an engine, a ladder and a chemical company in Roxbury and West Roxbury, an engine, a ladder and a chemical company in Dorchester, and 2 chemical engines in the downtown and Backbay districts. None of this apparatus responded to this alarm, 6 engine and 4 ladder companies, a chemical engine and 3 water towers being ordered from the Albany street fire, which was then under control. The time required for these companies to pick up, go to the High street fire and get to work was of course much longer than it would take second alarm apparatus to get to work under ordinary conditions. So that for over two hours during these two fires, 41 engines (7 from out of town), 2 fireboats, 12 ladder companies and 4 chemical engines were working at the Albany street fire, while 16 engines (8 from out of town), 8 ladder companies and 4 chemical engines were working on the High street fire, and the 3 water towers were at one fire or the other. Companies began to return to quarters after 11 P. M., but until the following day, the protection of many sections of the city was very weak, and during much of this time the protection in the adjoining cities was seriously weakened. From 6:30, when the general alarm was given, until 11 P. M., the situation was serious, and would have been much more so except for the assistance sent in from the surrounding towns. Such conditions are liable to occur at any time and are a strong argument for providing the additional protection of a high pressure system.

To sum up the advantages of the high pressure fire system: A large number of powerful streams can be concentrated on a fire in much shorter time and with fewer men and less apparatus than with fire engines, and at the same time the protection of the rest of the city would not be weakened to the extent now necessary on third and fourth alarms from the district covered by the system. It will deliver its full capacity at any point in the district covered and at any desired pressure, and can sustain this pressure as long as wanted. It eliminates the confusion entailed in the operation of a large number of fire engines, tends to prevent the misunderstanding of orders and in every way simplifies operation. Above all, it provides protection to the congested value district even with a general alarm fire under headway in another part of the city and is the greatest insurance against conflagration, forming an effective barrier against fires starting outside the district, and affording the most efficient check of fires in the district which might otherwise involve a number of large blocks.

Practical experience has shown that the following requirements should be met in the design of a separate high pressure fire system to insure good fire protection in districts it is to cover:

A fireproof pumping station, with all openings protected in an approved manner and removed from the zone of sweeping conflagrations. Station to be equipped with sufficient pumping units of moderate capacity to aggregate a total capacity of 20,000 gallons per minute at 300 pounds pressure, taking suction from a fresh water supply, and delivering into the gridiron system through well looped and gated discharge connections.

The distribution system to be connected with the pumping station through duplicate supply mains and to be so designed as to deliver the full capacity of 20,000 gallons per minute about any block within the area served, without excessive loss of head; to contain no pipes less than 12 inches in diameter, no dead ends and be connected at all intersections. Connections to be provided to the system so that the fire-boats may be used as auxiliary pumping stations in case of emergencies, and system to be provided with gate valves so placed that not more than 500 feet of pipe will have to be cut out at one time.

Hydrants to be of ample dimensions, with 4 independently gated hose outlets and connected to the mains through 8-inch gated connections; to be so distributed that the average area served by each shall not exceed 40,000 square feet.

MINOR FIRE EXTINGUISHING APPARATUS

Fire Extinguishing Agents.—Water is the universal extinguishing agent for use on fires, its principal value being the cooling effect it has; only when applied to a small fire or in very large quantities on a large fire, or in such a manner as to completely surround the burning object can it serve as an excluder of oxygen. The best extinguishers are those of a gaseous nature; carbon dioxide, sulphur dioxide and ammonia and the gases liberated by carbon-tetrachloride when applied to a heated object.

Of the three gases mentioned above, carbon dioxide is to be preferred, being cheaper, more easily obtainable, and safer to work with than the others, which are far more dangerous to man. When present in sufficient quantity (about 10 per cent) carbon dioxide—and in some instances sulphur dioxide as well—will render explosive mixtures of air and gases harmless.

In all cases where water is inadmissible, dry fine sand is suitable, and the blanketing effect of sawdust and like substances has been used successfully, if thrown on to the seat of the fire. Once used, especially when fires of oil or resin are in question, such sand, etc., should be thrown aside, and not employed again.

For extinguishing fire in special cases, the following substances and methods have proved most useful:

Fires of oil, fats, mineral oils, waxes, ozokerit, tar, resins, lacquer, varnish, carbon disulphide, alcohol, ether, benzol, acetone, wood spirit, and similar substances:

In the open: application of carbon tetrachloride, ammonia, chloroform, sand, earth, ashes, bags and clothes;

In closed rooms: exclusion of air, introduction of quenching gases or steam;

In tanks: putting on the covers;

With the oils and fats water should never be used.

Fires concerning acids, acid carboys and nitrating liquid:

Water must be used in all cases; never sand, earth, or even ashes. Tan, sawdust, or organic substances will only feed the fire.

Fires of gases, vapors, mixtures of air with gas or vapor:

In the open: chloroform, carbon tetrachloride.

Indoors: steam, exclusion of air.

In tanks: putting on the covers.

Fires in the centre of coal heaps:

At the outset: dividing into smaller heaps (surface cooling);

In advanced stages: water, but only in the event of a sufficient supply being available to thoroughly drench the whole heap; partial quenching will merely favor the progress of the fire.

Fires in waste heaps, dumped soda waste, pyrites, or substances containing metallic sulphides:

In the advanced stage (mostly internal conflagrations), water must never be used, on account of the risk of oxyhydrogen gas being formed, and of the liberation of combustible sulphuretted hydrogen.

Furthermore, when extensive heaps take fire there is nothing to be done but to stop up all openings, so as to prevent access of air. Small heaps should be opened out, thrown apart, and then quenched with water, if surface cooling does not effect the desired result.

Fire Pails.—Because everyone knows enough to throw a pail of water on a fire, the underwriters consider fire pails an added protection to any plant. The principal fault to be found with them is that usually when needed they are not in their regular place, but are being used in the boiler room to mix boiler scale compound, or out on construction work as water pails, or in any of a hundred different places or uses that a hand pail can be put to. To prevent this most fire pails are made so they will not be handy to use in this way.

Another cause of complaint is that they are seldom kept filled with water. Regular and systematic inspections is the only cure for this, although partial remedying of it can be obtained by providing a tank or barrel near by into which the pail can be dipped.

A very convenient form for fire pails is the combined pail and tank, the pail or pails nesting in the tank.

No set rules can be laid down for the number of fire pails necessary for every plant; there cannot be too many, particularly if the labor employed is ignorant and unskilled, and probably would not know how to use other appliances. In the Regulations on Fire Pails issued by the National Board of Fire Underwriters in 1903, the number and arrangement of pails was given as follows:

> NUMBER AND ARRANGEMENT.—To be placed as required by the underwriters having jurisdiction, not less than one dozen to every 5,000 ft. floor area, and to be hung on hooks or set on shelves arranged so that bottom of pail shall be not less than 2 feet or top of pail more than 5 feet from floor. Where other than flat bottom pails are used, the holes cut in shelves shall be only large enough to receive the oval, the flanges to rest on top of the shelf.
>
> Three pails and 1 filled cask of at least 60 gallons capacity, or 1 approved portable extinguisher and 6 pails to be considered the equivalent of 12 pails.

NOTE.—In all cases there must be at least the number of pails on each floor as required by the rule of 12 to each square feet floor area, i. e., only one-half of the pails required on each floor can be replaced by one or more chemical extinguishers.

It is very important, with all form of fire extinguishers, that a sign be placed immediately by it, to the effect that *SOUNDING THE ALARM OF FIRE IS THE FIRST CONSIDERATION.* It is impossible for the person to tell whether he is going to control the fire or not, and if he does not, and spends valuable time in the futile attempt, it will probably be too late for assistance from the fire brigade or public fire department to be of any use by the time he sends in the alarm after being defeated in his efforts of extinguishing the blaze. It was just such a case that resulted in the almost total destruction of the Edison plant in 1914.

Regulations for the construction of fire pails were last isued by the National Board of Fire Underwriters in 1903 and were as follows:

FIRE PAILS.—Size 8, 10, 12 or 14 quart, the medium size of 12 quart being the most generally used.

Bottom.—Flat, oval or cone shape (3½-inch pitch), or with rounded band across, at least ⅛ x 1 inch, bent to circumference of bottom, two rivets at each end.

Material.—Galvanized iron, raw sheet from stock to be not lighter than No. 28 gauge (.015 inch).

Construction.—To be assembled with lock-joints soldered or galvanized. Beaded rim around top of not less than No. 9 wire, and handles to be of not less than No. 6 wire. Ears for handles to be riveted to pail.

Covers.—Not considered essential but desirable. If used, to be of sheet iron stamped with depression fitting inside of top of pail and flat edge extending over edge. Knob or ring to be provided to remove cover.

Galvanizing.—To be done after the pail is made, entire pail to be dipped.

Painting.—To be painted red on outside and stenciled "Fire" in black letters 2½ inches high.

Painting inside of pail not required, but it is regarded an item of economy, in that it prolongs the life of the pail.

Marking.—Each pail must be plainly and permanently marked with its trade-name and the name, initials or trade-mark of the manufacturer.

These have been modified somewhat in their application by the Underwriters' Laboratories, Inc. In the list of Fire Appliances issued by the Laboratories the following statement is made:

Hand Fire Extinguishers made of iron, steel or fibre; pail type; operated by throwing liquid from pail; extinguishing agent used, water or solutions containing anti-freezing ingredients.

These appliances have been shown to be effective on incipient fires where water or solutions containing large percentages of water are effective, but on account of their form their use is limited to fires which may be readily reached by the liquid thrown from a pail. Their use on electrical arcs or machinery or wiring carrying high voltage, may be dangerous on account of the conductivity of the liquid. They are of little service in liquids of a flammable nature.

When water only is used they must be protected against frost. Where it is desired to protect the contents of exposed pails against freezing, by the addition of calcium chloride or other salts, inspection departments having jurisdiction should be consulted.

Protective users should first ascertain from the inspection department having jurisdiction under what conditions extinguishers of this type will be accepted, and should make contracts subject to approval by them of the setting, distribution and number to be used in respect to floor area.

Pails in Tanks.—The Underwriters' Laboratories give under this heading, the following:

Hand Fire Extinguishers consisting of six nested iron or steel pails immersed in water or suitable non-freezing solution in cylindrical steel tank. Tank capacities 22 to 40 gallons; pails 10 to 14 quarts.

These tanks are made to take the place of ordinary fire pails and have the advantage of storing liquid in a tight receptacle so that there is practically no evaporation.

Hand Pumps.—In the earlier days, and to a small extent by fire departments now, use was made of a small pump which set in a bucket and from which a stream could be delivered for a considerable distance. This has now been superseded by chemical extinguishers.

Chemical Extinguishers.—Various attempts have been made to apply the principle of generating gas chemically in a closed container and thus provide sufficient pressure back of a column of water to permit its use as a fire extinguisher.

SODA AND ACID TYPE.—Of the different forms the most common is the soda and acid extinguisher, in which the action of sulphuric acid on a solution of bicarbonate of soda generates sufficient carbonic acid gas to expel the water with good force. The gas itself acts as an extinguishing agent, and the soda solution, which must be of sufficient strength not to leave a trace of the sulphuric acid, as the acid would injure goods, has a slightly greater extinguishing effect than plain water.

The acid must necessarily be securely contained, to prevent a too early application, but must also have its container of such a type that sureness of operation will be obtained. Two general types are in use, one where the acid stopper fits loosely in the container and drops out when it is inverted and the other with a container which is ruptured by puncturing or pressure.

Such extinguishers can be made in any size, but usually are sufficiently small to be portable, whether on wheels or by hand. The sizes generally used are the 33-gallon wheeled tank for factory use, the 2½-gallon (standard size) hand extinguisher and the 1½-gallon hand extinguisher; the last is primarily for use by women and children and has approximately 60 per cent of the value of a standard extinguisher. Their construction, in so far as satisfaction to the Underwriters is concerned, is covered by the inspection service of the Underwriters' Laboratories'. In the list of fire extinguishers, the following is given:

> These appliances are effective on fires where water or solutions containing large percentages of water, are effective. Their use on electric arcs or wiring carrying high voltage may be dangerous on account of the conductivity of the liquid. They are of limited service in hazardous liquid fires. They must be protected from freezing. Subject to the above limitations these extinguishers are standard for general use.

All forms of fire extinguishers which have met the tests of the Laboratories have labels soldered on them, and as there is considerable danger of poorly constructed appliances being ruptured by the gas when put in use, it is strongly advised that labeled extinguishers be insisted upon, to lessen such danger.

COMPRESSED AIR TYPE.—A form of extinguishers used in large chemical engines of fire departments and to a less degree developed for small extinguishers is one making use of compressed air for the force to expel the fluid, which may be only pure water or may have ammonia or soda in solution. With 2 to 5 per cent solution of soda, it is claimed that the extinguishing force is greatly increased, the heat driving off carbon dioxide which settles around the fire and smothers it out; about 15 per cent of this gas in the air will extinguish flame. The larger of these air pressure systems, as used by the fire department, has a separate tank or tanks which are charged with air at high pressure; when put in use, the air is let into the solution tank through a regulating valve and discharges the liquid. These have some points not in their favor, principally the danger of leakage of the air and the need of maintaining an air pump of considerable power.

In some of the small hand extinguishers use is made of air or carbonic acid gas in a metal capsule similar to those used in charging vichy or seltzer. When these are punctured the liberated air or gas expels the liquid. None of these have been listed by the Underwriters' Laboratories, but it is believed they will be as they are further perfected, especially in connection with small extinguishers of the type described below.

Carbon Tetrachloride Type.—A form of extinguisher developed in recent years that has met the approval of the Underwriters is the small hand extinguisher seen generally around places where oils are kept or used. These as described by the Underwriters' Laboratories are:

> Hand Chemical Fire Extinguishers of about one quart capacity, utilizing as extinguishing agents special liquids.
>
> These appliances are effective on incipient fires in hazardous liquid, calcium carbide and rapidly burning materials (such as celluloid and celluloid products), and on incipient fires in cotton and fabrics. They are of service in fires

not easily extinguished by water. They are especially adapted for garages, automobile and motor boat use, and for electric arcs.

Because of the low freezing point of the extinguishing liquids (minus 50 degrees F.), these extinguishers are recommended for service where low temperatures prevail. They can be handled by women.

The various manufacturers furnish the liquid for recharging these containers and advise against using any other liquid; although the exact composition of these liquids is not known, the basis is carbon-tetrachloride in all of them, probably refined to remove some of the impurities that might cause corrosion of some of the parts. The earlier types were mainly sheet iron or tin, but these would not meet the Laboratories' tests, and now they are made of copper. The first type made was equipped with a pump, which worked inside the cylinder and discharged the liquid; improvements were made including the substitution of a double-acting pump. Other types have attempted the use of compressed air, but these, although better fitted for fire fighting, because of the greater ease in handling and in directing the stream, have not received the approval of several investigating bodies, including the New York Bureau of Fire Prevention and the Underwriters' Laboratories. The liquid absorbs the air and then the pressure is gradually reduced, until the extinguisher is useless. Frequent inspections and tests of the extinguishers, by means of the ordinary Schraders' tire tester, will prevent this possible loss of pressure being a danger, and where such tests can be made sure of, it is a very valuable form of extinguisher.

Other forms involve plungers which are operated by hand or air and drive the liquid out.

Chemical Extinguishers in Connection with Standpipes and Sprinkler Systems.—A recent development of the chemical extinguisher has been that of a stationary chemical-holding tank attached to a standpipe system, and this is being further developed to make it applicable to an automatic sprinkler system. For the system as perfected for standpipes, the Underwriters' Laboratories report:

Stationary Chemical Fire Extinguishers; for connection to a standpipe system provided with hose stations; cylindrical, tank made of Allegheny iron; liquid capacity 100 gal.; chemicals used, bicarbonate of soda and sulphuric acid. Extinguisher placed in operation by inversion of the acid receptacle, this being accomplished by creating a pressure difference between tank and distributing piping. This pressure difference is created by a fairly sudden reduction in pressure in piping, due to opening any hose valve, system normally being under air pressure.

This air pressure is required to cause operation of extinguisher, it is necessary that system of piping be tight, and that air pressure be maintained in system.

When properly installed, charged, and maintained in operative condition, these extinguishers may be expected to give satisfactory service in fires where water, or solutions containing large quantities of water are effective.

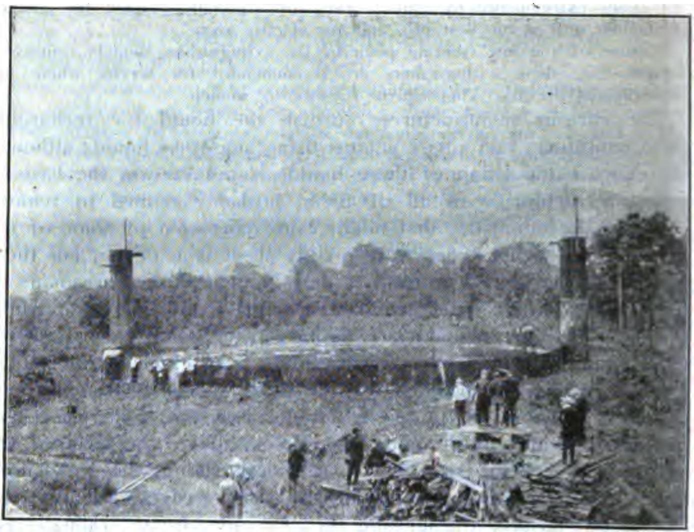

FIG. 74

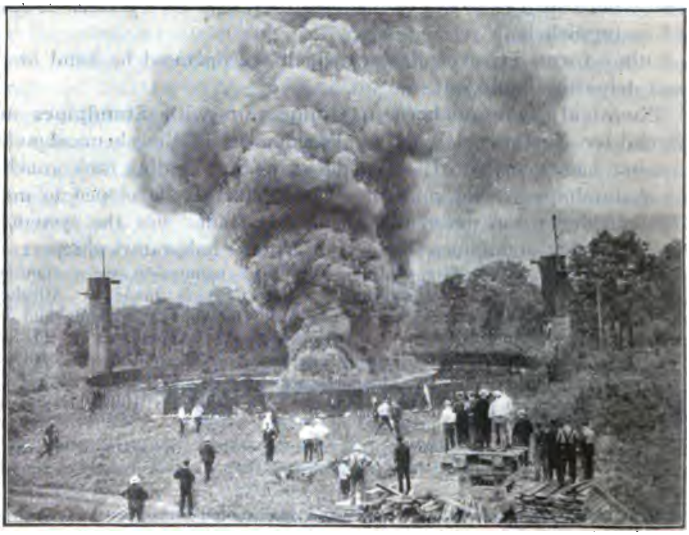

FIG. 75

Their use on electric arcs, or machinery or wiring carrying high voltages, may be dangerous on account of the conductivity of the liquid. They are probably of limited service on fires in large quantities of volatile liquids of a flammable nature. They must be protected against freezing.

Inspection departments having jurisdiction should be consulted before installation in regard to location of tank and standpipe, location of hose stations, quantity of hose at each station, provision for preventing tampering with device, and provisions for inspection and maintenance service.

Chemical Extinguishers for Tanks Holding Inflammable Liquids.—The principal difficulty in fighting fires in tanks has been to obtain a reliable extinguishing medium which could be easily applied. Because of the nature of the fire, the only good extinguishing agent is one having a blanketing effect, thus cutting off the oxygen from the fire and smothering it out. Steam has been the common agent used, but with little success as it tends to rise and is hard to confine to the surface sufficiently to exclude the air.

A recently perfected system, passed upon favorably by the Laboratories, makes use of the principle on which chemical extinguishers work. This system, known as the Erwin, consists of a tank holding a solution of bicarbonate of soda and soap bark in water. By means of fusible links extending over and into the inflammable liquid in the tank to be guarded, a hammer is held up, which, when released, breaks a bottle holding sulphuric acid. This combines with the soda solution and generates carbon dioxide, which, because of the soap bark, forms a foam; this foam is discharged onto the burning liquid and spreads over it several inches thick and thus smothers the fire out.

These installations are made in two forms, one called a "standpipe method" and the other, to be used where there is danger of freezing, called the "underground method." The system is reported by the Laboratories as being suitable for all tanks up to 55,000 barrels capacity.

Figures 74 and 75 are views of a test made of a tank 114½ feet in diameter, with a fire started in the middle; Figure 76 was taken 3 minutes and 20 seconds after the tank was ignited and just as the extinguisher began working; Figure 78 was taken just before the fire was extinguished, which required 1 minute and 35 seconds after the foam first appeared.

In an article on oil fire-extinguishers for naval vessels, by Henry Williams, printed in the *Engineering News* June 5, 1912, is the following account of the use of a form of foam extinguisher:

> The adoption of oil fuel for naval vessels has introduced an element of considerable danger from fire. Due to leakage, which it is practically impossible to prevent, from manholes, pipe connections, pumps and seams in tanks, oil collects in the bilges of the fire rooms. The surfaces with which it comes in contact remain coated with a film of oil, which burns freely when ignited

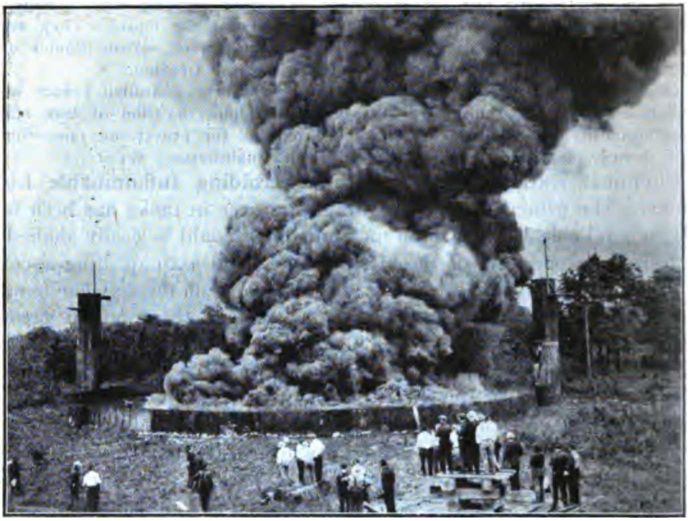

FIG. 76

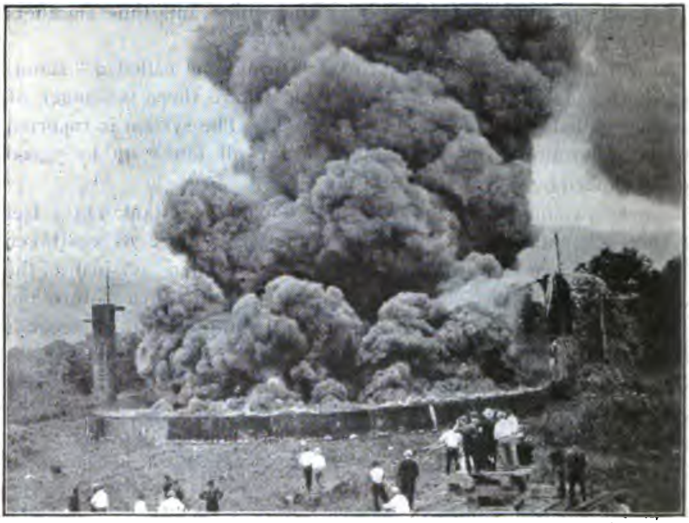

FIG. 77

or heated, communicating the fire to any oil that may be exposed. This constitutes a danger and already there have been several fires which fortunately have not resulted in serious danger to the ships, though all of them presented that possibility.

The extinction of such fires, once they have gained headway, is difficult. Water has no effect, as the burning oil simply floats on the surface of the water. Sand is more effective, acting to smother the fire. It must cover, however, the entire surface that is burning, and as it does not flow, must be applied locally. This is difficult for portions of the bilges under boilers or other obstructions, and the use of sand thus does not offer an entirely satisfactory guarantee against oil fires.

Recognition of these circumstances led the Bureau of Construction and Repair of the Navy Department to undertake experiments looking to the development of suitable fire-extinguishing appliances to meet the possibility of such fires and to insure their prompt extinction. A board was appointed to investigate the subject and to undertake the necessary experiments to determine the suitability of the various systems.

The most promising methods that presented themselves to the board were those whereby advantage is taken of a heavy foam mixture which, when applied to burning surfaces of oil, flows over them and smothers the flame by shutting off its air supply. These foam mixtures have been tested extensively abroad, especially in Germany, and have given results uniformly satisfactory.

Portable extinguishers were designed similar in shape and sizes to the chemical fire extinguishers seen in buildings on shore. These have the liquids in separate compartments and by inverting the extinguisher, or in later models breaking the acid container, the foam mixture is obtained and sufficient force generated to throw the foam a distance of about 20 feet. Two extinguishers of this type are supplied in each fireroom of oil-burning vessels. The question is under consideration of making stationary installations of greater capacity in the firerooms of oil-burning torpedo boat destroyers, and experimental installations of this character are being made. It is by no means sure, however, that this system of extinguishing oil fires will prove a success on shipboard, though it may be accepted that its efficiency for shore purposes has been demonstrated beyond doubt. One of the most important difficulties that may be encountered is the possible effect on the crew of the carbon-dioxide gas given off by the foamy mixture. Ten per cent of this gas in air has been known to prove fatal, and continued breathing of 2 per cent is dangerous. In closed spaces, such as firerooms, where fires are apt to occur, especial care will need to be taken to prevent accumulation of this gas when the apparatus has been used.

Another difficulty and one that may render the system ineffective when needed is the liability to deterioration of the mixtures or the loss by evaporation of the water in which the solutions are made.

The corrosive action of the acid mixture on the containers and piping has been met in shore installations by lead-lining them. The excessive weight required, however, is an obstacle to this means being adopted for shipboard installations, and in those now being fitted up reliance is placed on acid-resisting paint to prevent corrosion. It seems probable that this will not prove adequate and that corrosion of the tanks and piping will take place, and that such valves as are used will be rendered ineffective in a short time.

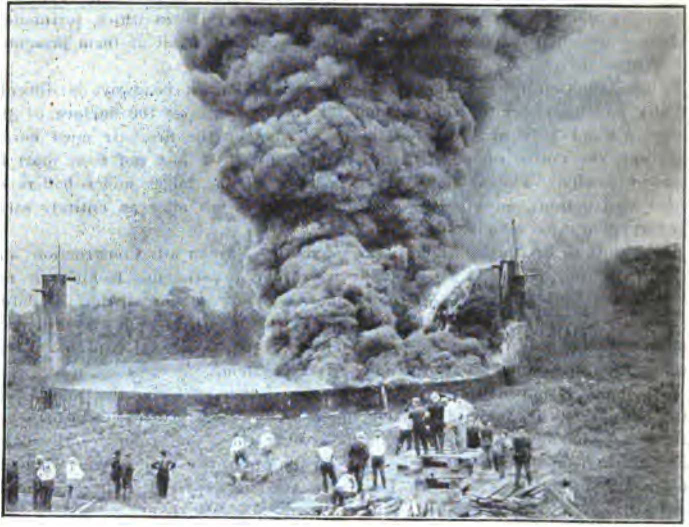

FIG. 78

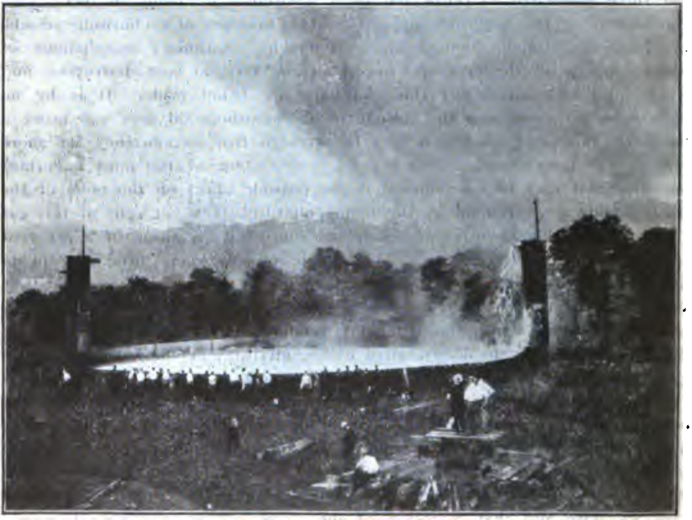

FIG. 79

The formulas for the mixtures are as follows:

LIQUID No. 1

	Parts by Weight.
Glue	1
Glucose	½
Soda Bicarbonate	7½
Salicylic acid	¼
Water	100

LIQUID No. 2

	Parts by Weight.
Aluminum sulphate	10
Sulphuric acid	½
Water	100

Carbon-dioxide gas is generated by the mixture of the soda bicarbonate and aluminum sulphate. The glue renders the liquid viscous and causes it to produce the foam. The salicylic acid is added as a preservative for the glucose, which is intended as a stabilizer to prevent the too sudden precipitation of the aluminum hydroxide. The sulphuric acid aids in starting the reaction and acts also as a stabilizer. It is possible that it may be found that the acid itself can be omitted and in such an event the corrosive effect of the mixture on the container and piping will be reduced considerably.

STANDPIPES IN BUILDINGS

Functions of Standpipes.—The functions of standpipes in buildings are two-fold, to enable the occupant to extinguish a small fire and to be an auxiliary for the fire department or a trained fire brigade in coping with serious fires, either in the building equipped or in a near by building. Because of these differences the National Board of Fire Underwriters has considered it necessary to divide the requirements into two sections in treating the subject in the latest revision of the National Board's Building Code, from which the requirements given below are copied.

Occupant's Use.—The first function, that of use by the occupant, is one which is applicable to practically all buildings, but is not considered an essential unless the building is of considerable size; in the smaller buildings, chemical extinguishers, pails of water, etc., are usually sufficient to control the fire until the arrival of the fire department. For use of untrained men, small hose is a necessity, and also small hose permits quicker and surer work and does not tend to give the excessive water damage that usually results from untrained handling of large hose and nozzles. As a standpipe for this use must be immediately available it is necessary to have water constantly in the system; there will not have to be a large supply available to maintain this flow, as if the fire can not be controlled within about 30 minutes, such streams will be of no avail. As given in the requirements below, it is recognized that one standpipe system can serve both purposes, but in buildings of excessive area this is not feasible unless branches are run on the various floors to give the proper distribution of the smaller lines.

Fire Department's Use.—In considering standpipes for fire department or fire brigade use, it must be recognized that one of the principal uses is in fighting a fire in an adjoining building or one across the street; this has not been very general in the past, but fire chiefs are awakening to the advantage thereby gained and in a few more years it will be a very general practice. In the Equitable building fire in New York, every standpipe in nearly every building was put in service. As exemplified in this fire, as many as 4 lines may be taken from one standpipe and because of this it is very essential that the old idea of providing a 2- or 3-inch standpipe must be discarded, and one of liberal size required.

It is practically impossible for a fire department to fight a fire in a high building or one of great depth, using only lines from the outside; to lay hose lines up ladders and stairs to above the 4th floor is a tedious and long task giving a fire a great chance to spread, but where the engines can connect to the siamese inlet of a standpipe and the firemen have only their nozzles and one or two rolled lengths of hose to carry up the stairs or elevator, quick work can be done.

Standpipe Hose.—It is a more or less general practice for firemen to use their own hose from standpipe outlets and not that provided by the buildings' owner. This is due in part to the fact that they are not familiar with linen hose, the type recommended because of durability, and consider it unreliable because it will leak until the strands have time to swell; but an even greater defect exists, it is often in too poor a condition to be used. As the firemen so seldom use it and smaller hose must be provided for the use of the occupant, it might be argued that there was no necessity in providing 2½-inch hose on fire department standpipe; it is the opinion, however, of some of the more progressive chiefs, that it should be provided, as at times it is used and in such cases it is of vital value.

Water Supply for Standpipe.—Where provided primarily for use of the fire department, a standpipe does not have to be provided with a water supply, as this can not easily be provided in sufficient quantities for an extensive fire and the supply can be obtained from the fire engines through the siamese connection at the base. In the western coast cities standpipes for fire department use are required in conjunction with or near the fire escape; it is considered that this is satisfactory, although greater use could probably be made of it if it were inside the building.

FRICTION IN POUNDS IN STANDPIPE PER 100 FEET*

Gallons	4-Inch	6-Inch
200	2	0.3
300	4	0.6
400	7	0.9
500	10	1.4
600	14	2.0
700	19	2.7
800	24	3.4
900	30	4.3
1000	37	5.2
1200	52	7.5
1400	69	10.0

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* An allowance equal to 100 feet of pipe should be made for loss at siamese, in bends, etc.

STANDPIPES FOR PRIVATE PROTECTION*

1. In existing and new buildings three stories and higher, except as given below, there shall be provided a standpipe, not less than 2 inches in diameter, with water supply constantly maintained or furnished automatically with the opening of a hose valve.

Exceptions: Buildings equipped with inside standpipe for fire department use (see page 533) and having also 1½-inch connections with hose attached, and automatic water supply, all as provided in paragraphs 2, 3 and 4 of this section;

Dwellings;

Churches;

Other buildings having maximum undivided fire section of less than 2,500 square feet area and provided with at least one 2½-gallon approved chemical extinguishers to each fire section;

Sprinklered buildings where the requirements of this section are met by connecting hose to sprinkler riser.

2. Supply shall be from one of the following sources:

Street main, where pressure is sufficient to maintain not less than 25 pounds at hose outlet in top story;

Gravity tank of 2,500 gallons capacity, with bottom 25 feet above outlet in top story;

Pressure tank of 3,750 gallons capacity, located in top story or on roof;

Automatic pump of at least 250 gallons a minute capacity.

Provided that, if standpipe is intended also for fire department use (see page 533), tank or pump capacity shall be at least double that given above.

3. Where a standpipe is connected to fire pump or provided with Siamese connection, a straightway check valve shall be provided in connecting pipe to tank, and tank filled by a separate pipe; and where the water in such tank is also used for house supply, the house supply pipe shall extend above the bottom of the tank to such a height as will reserve for fire purposes not less than the quantities required in paragraph 2.

4. Standpipes shall extend from the cellar to the roof, with a 1½-inch hose connection and gate valve, not over 5 feet above floor level, in each story, including cellar and roof.

Hose sufficient to reach to all parts of the fire section, but not in excess of 100 feet, shall be attached to each outlet; hose for roof outlet may be placed on rack in top floor near the scuttle leading to the roof. Hose shall be 1½ inches in diameter, and provided with nozzle having ½-inch discharge outlet.

Editor's Note.—In a report on standpipes made by a committee of the National Fire Protection Association in 1914, it was recommended that no hose line of over 50 feet be allowed, as with the longer lines, the troubles in handling was much greater and the hose was more liable to kink. Semi-automatic hose racks were recommended; several of these are approved by the Underwriters Laboratories and are reported as "Suitable for use in connection with inside standpipe systems at pressures not in excess of 150 pounds to the square inch. Designed to permit one man to accomplish all the operations necessary in putting a line of hose into service."

5. Standpipes and hose shall comply with the requirements of Standpipes for Fire Department Use (page 533), paragraphs 3, 4, 7 and 9, except that 150 pounds test pressure will be required.

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*As given in the 1915 edition of Building Code recommended by the National Board of Fire Underwriters.

STANDPIPES FOR FIRE DEPARTMENT OR FIRE BRIGADE USE*

1. In existing buildings not already provided with a 4-inch or larger standpipe, and in buildings hereafter erected, there shall be provided:

a. For buildings in excess of four stories or 55 feet in height, and not within 75 feet of exposing buildings, a standpipe not less than 4 inches in diameter;

b. For other buildings in excess of four stories or 55 feet in height, a standpipe not less than 5 inches in diameter;

c. For buildings in excess of six stories or 75 feet in height, a standpipe not less than 6 inches in diameter.

2. Standpipes shall be located within fireproof stairway inclosures. Provided that, where existing buildings do not have such inclosures, the standpipes shall be as near stairway as possible, or shall be on the outside of, embedded within or immediately inside an exterior wall and within 1 foot of a fire escape or fire tower.

3. One standpipe shall be provided for each separate fire section exceeding 2,500 square feet area, with at least one standpipe within 75 feet of every exterior wall in the building.

4. Where more than one standpipe is required in a building they shall be connected at their bases by pipes of size equal to that of largest standpipe, so that water from any source will supply all the standpipes.

5. Standpipes shall extend from the cellar to and through the roof, with a 2½-inch hose connection and gate valve, not over 5 feet above floor level, in each story, including cellar, and two 2½-inch hose connections, with gate valve for each, in the roof; roof connections to have a controlling gate valve under the roof and arranged to be operated both from above and below the roof, with three-quarter-inch drain pipe and valve to prevent freezing. Valves to be of a type giving a straight 2½-inch water way.

Note.—Gate valves are not suitable for these outlets, as it is practically impossible to keep them tight. An angle globe valve, similar to that used on boiler blow-offs, is recommended.

6. Where standpipes are located inside of building, hose sufficient to reach to all parts of the fire section, but not in excess of 100 feet, shall be attached to each outlet, with hose for roof-hydrant either in hose house on roof or on rack in top story near roof scuttle. Hose shall be not less than 2½ inches in diameter, and provided with standard couplings in use by the local fire department.

7. Hose to be approved linen in 50-foot lengths, made under specifications recommended by the National Board of Fire Underwriters.

8. Each line of hose shall be provided with washers at both ends, and be fitted with smooth-bore brass play pipe or nozzle at least 12 inches long, with discharge outlet 1⅛ inches in diameter. One spanner to be located at each hose connection.

9. Standpipes shall be wrought iron or steel, galvanized; valves, fittings and connections shall be of cast steel, brass or malleable iron. They shall be of such strength as to safely withstand at least 300 pounds' water pressure to the square inch when ready for service, without leaking at joints, valves or fittings; such test to be made by the chief of the fire department.

10. Standpipes shall be connected by a pipe of diameter equal to that of the largest standpipe supplied, to a Siamese steamer connection outside of

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*As given in the 1915 edition of Building Code recommended by the National Board of Fire Underwriters.

the building, on each street front, except that corner buildings having one street frontage of less than 50 feet may have only one connection. Siamese shall be about one foot above the curb level, and shall be provided with check valves, and substantial caps to protect thread on the connection; the thread shall be uniform with that used by the local fire department. A suitable iron plate with raised letters shall be provided, reading: "To Standpipe."

Just inside of the building, in a horizontal section, shall be placed a straightway check valve. A drip pipe, with valve to same, shall be placed between said check valve and Siamese connection to properly drain this section to prevent freezing. Similar drip pipes shall be provided for all pockets or low places which will not normally drain.

11. Fire pumps, permanently connected to the standpipe system, shall be provided for buildings eight stories or more in height and in any building in excess of 10,000 square feet area, with capacities as follows:

One 5-inch standpipe, pump capacity not less than 500 gallons a minute;

One 6-inch standpipe or two inter-connected 5-inch standpipes, pump capacity not less than 750 gallons a minute;

Two 6-inch standpipes, pump capacity not less than 1,000 gallons a minute.

Pump to have an adequate source of power and be supplied from street main or from well or cistern containing at least one hour's full supply; suction piping to be well installed.

12. In every building exceeding one hundred feet in height, at least one passenger elevator shall be kept in readiness for immediate use by the fire department during all hours of the night and day, including holidays and Sundays.

Special Standpipe Fittings.—It has been argued that in the higher buildings, that is, buildings of a height too great for water tower streams, a means should be provided by which a powerful stream could be thrown on to the fire on any floor without the firemen going inside the building or to the floor on which the fire exists. Buildings of this class could of course be protected by sprinkler systems but a fire getting beyond the control of the sprinklers, as sometimes happens, would be a serious matter to fight without a standpipe to aid. A standpipe embodying this feature has been patented and installed in several buildings; in general design, it consists of a 4- or 6-inch standpipe of the usual form, but so hung and fastened at each floor that raising or turning the pipe is possible. The raising is accomplished by having the bottom of the standpipe in the form of a plunger, which, by means of the water pressure available, permits the standpipe to be raised at will. Revolving the standpipe is accomplished manually. Small brass pipes extend from a control box at the bottom of the standpipe to hydraulic valves on each floor which control the flow through nozzles attached to the standpipe, thus permitting any story to be swept at will.

AUTOMATIC SPRINKLERS

In all matters of fire protection it is recognized that if an extinguishing agent is applied in the incipient stage of the fire, it will tend largely towards preventing a serious fire; this is particularly true where a hazardous or quick burning substance is present.

The most efficient means of applying the extinguishing agent during the early stages of a fire is the automatic sprinkler. Because of cost, such systems are generally designed and supplied on the basis of extinguishing only a small fire and never one requiring the opening of more than the sprinklers in one fire section of any story. They are, however, provided with steamer connections, through which the fire department can pump water, or have a connection to a fire pump. By this means, much larger flows can be obtained, thus making a sprinkler system of great aid to the fire department in fighting a fire which has reached large proportions. It has, in this connection, the great advantage of placing the water directly on the fire, a condition which can not be obtained in a smoke-filled room with hand lines. For this reason some fire protectionists recommend installing sprinkler piping throughout a city, with only steamer connections, to be used by the fire department. In many cities, the requirement is made by ordinance that cellars and basements be equipped in this way.

There can be no doubt that such a system is of value, but it does not have the full automatic feature, as no water supply is available until the fire department connects into it, and in many cities this would not be done. To be of full value, it must come into service with good force in the very earliest stages of a fire.

PRIVATE FIRE CONNECTIONS FROM CITY MAINS.

There has been much discussion of this subject in the past few years, both as to the advisability of making such connections and as to the necessity of limiting the sizes of the connections or otherwise restricting them. Some have thought that no restrictions should be placed by the city authorities on the size and number of connections; that they should be limited only by the size of the street mains and the desires of the building owners, while others have gone so far in the other direction as to contest any large connections whatever. It is evident there should be a happy medium, connections which will be small enough for safety and yet large enough for efficiency. In this connection a glance at the experience of the Associated Mutual Fire Insurance Companies will be of value, as they have had more experience with automatic sprinklers than any other organization. These companies are purely mutual, and their efforts are directed toward the prevention of fires and the development of appliances designed to reduce the fire loss.

In the '60s and early '70s the automatic sprinkler had not been invented, but mill buildings were quite generally equipped with standpipes and perforated pipe sprinklers, normally empty, with outside gates to be opened in case of fire. In those days the cost of mutual insurance, which is the actual loss plus a small amount for inspection work, etc., was about 32 cents per $100 of value insured. In the decade 1900 to 1910, with nearly all mutual mills sprinklered, the cost was 6½ cents per $100 of value, or in other words, the fire loss had been reduced 80 per cent. The mutual companies are unanimous in ascribing by far the larger part of this saving to the automatic sprinkler. In the '80s, there were still some doubts as to the efficiency of sprinklers, so a table was compiled of fires in mills, between 1877 and 1887, with this result: at 759 fires in sprinklered buildings, the average loss per fire (including the water damage of course) was $1,080, or only one-seventh as great as in the unsprinklered mills. This you will note was in large buildings, mainly with highly inflammable stocks, and is a most remarkable showing, for at that time the automatic sprinkler was far from its present perfected state.

Although automatic sprinklers have been in use now for many years and have proven their efficiency and value over and over again, yet it is still impossible to convince the average business man against his will that they would be desirable or profitable in his particular case. In fact, about the only way the average concern can be induced to install them is by the reduction of insurance premiums by 50 to 75 per cent. The building ordinances of most cities offer no encouragement to the would-be progressive citizen. such as limiting areas or heights of buildings except where improved construction or automatic sprinklers are used, and many fire departments are loath to make use of the evident advantage offered by the sprinkler connections, of providing means whereby water may be thrown directly into the heart of a fire, in places and under conditions where no fireman could live. As for the water-works officials, their ideas may be often summed up as: All you care to pay for at meter rates, and what is left over, for fires. Some water departments, in the endeavor to make a good showing in the ledger account, charge extortionate prices for water supplies for private fire protection, thus nullifying the efforts of the fire department and insurance interests to secure such installations.

In order to determine the general practice of waterworks officials with regard to fire service connections to city mains, in 1912, a National Board engineer communicated with 75 representative American cities, and asked a series of questions covering the subject, with the following results: About four-fifths of the city works and one-third to one-half of the private works make no charge or only a nominal charge for fire connections; the rest charge all the way from $22.50 to $120 per annum for various 6-inch connections, the companies generally charging the higher figures. Such rates as $105 and $120, which two western cities charge for connections used only for fire purposes, together with the expense of installation, interest, etc., will go far toward balancing any saving in rates the ordinary property owner would make by installing standpipes or sprinklers, and in effect act to penalize him for reducing his hazard and the exposure to his neighbors. Of course the taxpayer must also pay his share of the general city fire protection. About one-third do not limit size of connections; where any limit is placed there is a decided leaning toward six inches as a maximum. As to measuring devices on connections, over half do not require meters, one-third require detector meters and the rest other types. This corresponds well with the insurance requirements, that either no meters be used or some form, such as a detector, which will not retard heavy flows. As regard gates and check valves, there is great diversity, but about half of the cities have no rules or only require a gate at the street mains; the rest require also one or more checks, especially if there is another source of supply from which contaminated water might work back into the street mains. There are numerous schemes to prevent or discover theft of water; inspection alone appears unsatisfactory, but in conjunction with sealed outlets seems to work all right; the detector type of meter appears satisfactory, but is expensive. Several cities state that meters will be installed if any water is used illegally. The experience of the majority appears to be that illegal use of water may be prevented with a fair amount of certainty. Where the detector meters are objected to on account of expense, the prohibition of other connections from fire lines, sealing of test and draw-off valves, hose gates, etc., and regular and careful inspections have been found effective; the property owner would not object to a charge sufficient to pay for monthly inspections or tests.

The usual sources of supply to automatic sprinklers are:

1. From a gravity tank above the highest line of sprinklers.

2. From a pressure tank; to be above the highest line of sprinklers if possible.

3. From the public water supply by direct connections.

4. From the public water supply through the fire department hose and siamese connections.

5. From stationary fire pumps, which may be supplied from a stream, reservoir or cistern, or from water mains.

For a standard sprinkler equipment, two sources of supply are required. At least one of these should be automatic and one should be capable of furnishing water under heavy pressure.

The standard rules of the National Board of Fire Underwriters, as recommended by the National Fire Protection Association, state that the pressure connections should be capable of furnishing 25 pounds static pressure, at all hours of the day at the highest line of sprinklers and also able to maintain 10 pounds pressure on the highest sprinklers with the water flowing through the number of sprinkler heads liable to be opened by fire at one time. This number would probably be all the sprinklers on one floor dependent on one riser. The requirement for 25 pounds static pressure at all hours appears high, and would bar out many cities where the public supply will furnish only 10 or 15 pounds at the top of a 5-story building. This would mean 25 to 40 pounds at the street level, which is a common figure in the large cities and in parts of almost any city. Even though not up to standard, 10 or 15 pounds will produce very effective sprinkler streams.

The Committee on Fire Prevention of the National Board of Fire Underwriters has for a long time recommended that automatic sprinkler equipments be required in buildings which, by reason of size, construction or occupancy, either singly or combined, might act as conflagration breeders. For such equipments it recommends direct connections from the street mains where pressures are high enough to be effective, with controlling valve in the street.

If the street mains are large enough to provide ample supply, even at low pressure, this is no doubt the most reliable source, next to a detached, elevated tank. How large shall the connections be and how arranged? The National Fire Protection Association, which is the best authority on these questions, says that for sprinkler equipments or standpipes in closely built districts, 4-inch connections should be used where they will furnish ample water. Usually this can be arranged by dividing the system into 2 or more sections or taking 4-inch connections from well separated points on the street mains or from different mains on separate streets, as where a building is on the street corner or runs through the block to another street. Where pressures are low or the street mains small, often 4-inch connections will not furnish enough water and 6-inch pipes must be used, as it is well-known that the friction loss in 4-inch pipe is about seven times as great as in 6-inch pipe.

The original theory of sprinklers was that a few heads would open and control a fire at the start, and if a fire should gain headway, or should be communicated from an unsprinklered building, the sprinklers probably would not hold it. But it was found by experience that liberal supply pipes and ample water would permit the sprinklers to do much greater work; thus, they could protect the centers of large buildings or the upper floors of high buildings or similar areas, which would be out of the range of hose streams.

In many cities where joisted buildings are being but slowly replaced by improved construction, the sprinkler is the chief means by which sweeping fires can be prevented. Even in high fireproof buildings, where contents are combustible, sprinklers are the only means of preventing severe losses; they could have prevented the terrible loss of life at various factory fires in recent years.

But there is another feature to be considered. During a large fire, pipes will break, water leak out and, if the leak is big enough, the whole public system will be so bled as to make hydrants worthless, and cripple the fire department; such was the case in the Salem conflagration. So that we must find some happy medium, such size of supply pipes as will not endanger the public supply if broken and yet will be large enough to furnish ample water under working conditions. Then the supply must be safeguarded so that a broken line can be shut off speedily and securely.

Sprinkler experts tell us that in large installations the cost of two 4-inch connections and risers is not appreciably greater than for one 6-inch (except for meters), and the arrangement presents decided advantages, especially the possibility of maintaining partial protection during shutdowns due to repairs or alterations. In some cities we find connections to sprinklers as large as 8- or 10-inch. This is now regarded as bad practice, except perhaps for isolated buildings, from which fires could not spread to other property and where broken mains could be shut off at the street corner without robbing the fire engines of water for the protection of neighbors. For it is evident that a broken 6-inch or larger connection would cripple the fire department in the immediate vicinity until the controlling gates could be closed. Therefore, it is recommended that sprinkler and standpipe services shall have an outside controlling valve set in one of these ways:

a. At the curb, with an indicator post.

b. At the building line, with an indicator post in a recess in the wall.

c. In a valve pit in the street or at the curb.

d. In bad cases, the connection to be looped back and the gate set at the opposite curb across the street, or opposite an adjacent building.

There have been various fires where falling walls or other wreckage, snow, or ice, etc., have prevented the shutting off of the large sprinkler connections, after the fire got beyond control of the sprinklers and reduced the pressure in the mains so that direct hydrant streams were valueless and the engines could not obtain sufficient water. All the fire department could do was to save the surrounding property. If the sprinkler connections had been at the corner of the building or a little beyond the front, in these cases, it would have been a simple matter to close the gate. Sometimes the connection can be gated in front of a stair tower or heavy division wall, where there is less chance of falling walls making it inaccessible.

The fire department should keep track of these connections and be sure that they are properly marked to be quickly located at need. The waterworks men are frequently not available at such times and the prompt closing of a broken connection may make a vast difference in the eventual outcome of a fire. It is not always a falling wall that makes trouble; many things may cause a serious break inside a building—a floor or roof falling, or heavy machinery or safes dropping and, when the break occurs, then the sprinkler connection becomes a detriment instead of a help to the firemen. Care should be taken that any main supplying automatic sprinkler systems or standpipes shall be properly gated at each end of the block, so that in extreme cases it will be feasible to cut a short section out of service without interfering with other supplies. In a narrow street the heat of a fire will often render gate valves inaccessible, or in winter the snow may be piled up so they can not be quickly located.

There should also be a check valve, or preferably two, in the connection between the indicator gate and the riser, so that water will not be drained from the tank during shutdowns of the street mains, etc., and also in case of systems having stationary pumps, so that water, possibly infected with disease germs, may not be pumped back into the street mains.

A recent suggestion for safeguarding fire connections is to place an electrically operated valve in a concrete vault in the street or at the curb. This can be controlled from any distant point, as each end of the block, or at the nearest fire alarm box, where a small locked box with controlling switch may be placed, the key to be in possession of the fire chief. Then if for any reason the chief should find the sprinkler or standpipe connection taking too much of the supply for his engines, he could at once and with certainty shut them off. Of course, this apparatus must be properly installed and regularly tested; it would seem specially valuable where connections are made to high pressure systems and the additional expense would not be a deterrent feature compared with the need of certain means of control. As a substitute for the electrically operated valve, there is the hydraulically operated valve; this may be designed to use the water pressure in the pipe for closing, or an arrangement could be made by which it could be closed by pumping oil or water through a small pipe from a tank located at some distant point.

There has been much discussion as to the advisability of allowing connections from high pressure systems for private protection; either to yard hydrants, standpipes or sprinklers. To the yard hydrants there is little objection, if they are made to withstand the high pressures and are regularly inspected like street hydrants. The sprinklers and standpipes are not ordinarily designed for such high pressure, and especially the severe "hammer" or shock caused by sudden increase of pressure. One can imagine what might happen to an automatic sprinkler system if suddenly subjected to the 300 pounds pressure of the New York High Pressure System, or even to 200 pounds. Recent improvement in design of regulating valves has probably overcome much of this danger, however. These valves may be attached at the gate in the street and set to limit the pressure to the sprinklers at any desired figure; they are claimed to be so reliable that pressures may be held within 5 pounds of the predetermined figure, no matter how much higher the pressure in the street mains may rise, But there is the danger of private connections being so used as to bleed the high pressure system and render it ineffective for fire department use. During the great Dreamland fire at Coney Island, in May, 1911, it is stated that over 20 streams were used by adjacent property owners who had standpipe connections, to wet down buildings and roofs. As the total capacity of the Coney Island High Pressure System was only 4,500 gallans per minute, and one of the pumps broke down, leaving only 3,000 gallons per minute during most of the fire, it will readily be seen that few efficient hydrant streams could be obtained by the fire department. On the whole, it seems best to reserve these high pressure systems solely for fire department use and to take no chances of lost pressure in an emergency, unless it shall be found safe to use some combination of electrically-controlled gate valves and pressure reducing valves, as explained above. Where the systems are properly designed, with multiple outlet hydrants closely spaced, it is readily feasible to run short lines of hose from the nearest hydrant to the siamese connections of the sprinklers and standpipes, thus giving ample water for severe fires. Any properly designed sprinkler outfit should have sufficient tank capacity to feed the system until the firemen can attach these lines; especially in these days of motor apparatus and speedy response.

To sum up—the experience of many years has proven conclusively that automatic sprinklers are of immense value as fire extinguishers and conflagration stoppers, therefore all should unite in urging and extending their use. To secure best results, a large and reliable supply of water is needful; this in most cases will mean connections to the city water mains. These connections should be large enough to furnish the required supply, but not so large as to hamper the fire department and endanger neighboring buildings in case of breaks.

Both theory and practice indicate that in most cases one or more 4-inch connections properly arranged are sufficient for well designed standpipe or sprinkler systems, and that 6-inch connections are the largest that can be safely permitted in a built-up district. Every such installation is of value both in controlling fires originating in the protected premises and in preventing the spread of fires in adjacent buildings.

The waterworks officials should encourage such installations by refraining from prohibitive rates and regulations for fire connections, and the fire departments should keep fully informed as to the location of gate valves and siamese connections, so that in case of fire, water may be pumped to the sprinklers so long as these work, and in case of accident, gates may be promptly closed to stop leakage of water and loss of supply for the engines.

THE INSTALLATION OF AUTOMATIC AND OPEN SPRINKLER EQUIPMENTS*

The rules contained herein cover the general details of a sprinkler equipment only. Before an equipment in installed, or before a present equipment is remodelled, complete working plans should be submitted for approval to the Inspection Department having jurisdiction.

These plans should be drawn to an indicated scale; give correct address and points of compass; show sectional elevations of the buildings; and the essential features of the construction, viz., size,

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* Regulations prescribed by the National Board of Fire Underwriters.

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location and direction of joists, timbers or other structural members. They should also indicate the location and size of water supplies, connecting pipes, feed mains and risers, gate, check, alarm and dry-pipe valves, as well as the location, spacing, number and type of sprinklers.

Inspection Department having jurisdiction and the lists published by the Underwriters Laboratories should be consulted as to standard makes of automatic and open sprinklers, gate, check, alarm and dry-pipe valves, indicator posts and hydrants.

Section A—General Information

1. **Preparation of Building.**—Many buildings require preparation for sprinkler equipment. All needless ceiling sheathing, hollow siding, tops of high shelving, needless partitions or decks should be removed. Necessary "stops" to check draft, necessary new partitions, closets, decks, etc., should be put in place, or provided for, so that the equipment may conform to same. The top flooring should be made thoroughly tight. Paper or similar light inflammable ceiling sheathing is objectionable and unnecessary. (See Section B, Rule 13.)

2. **Accessory Construction.**—Sprinkler equipments require accessory construction, dry pipe valve closets, ladders, anti-freezing boxing for tank pipes, etc. This work should be promptly attended to if not let with sprinkler contract.

3. **Vertical or Horizontal Drafts.**—Floor or wall openings tending to create vertical or horizontal drafts, or other structural defects that would prevent the prompt operation of automatic sprinklers by preventing the banking up of the heated air from the fire, should be properly "stopped" in order to permit specific control by the local sprinklers.

Satisfactory curtain-boards and other draft-stops must be provided to overcome such structural defects.

Except in special cases the main feeders to sprinklers are only of sufficient size to supply the sprinklers on one floor, consequently it is absolutely essential that these requirements for protection of vertical shafts should be carried out in every detail, and where extraordinary conditions exist and there is likelihood of fire passing through unprotected openings, pipe sizes should be increased accordingly.

4. **Clear Space Below Sprinklers.**—Full effective action of sprinklers requires about 24 inches wholly clear space below the sprinklers, so they may form an unbroken spray blanket from sprinkler to sprinkler and sides of room. Any stock piles, racks or other obstructions interfering with such action are not permissible. Sprinkler piping should not be used for the support of stock, clothing, etc.

5. **Experienced Workmen Recommended.**—Sprinkler installation is a trade in itself. Inspectors cannot be expected to act as working superintendents, or correct errors of beginners. Sprinkler work should be entrusted to none but fully experienced and responsible parties.

Care must be taken that after pipes are cut they are properly reamed in order to remove all burrs and fins; also that threads are cut to standard so that joints will be properly made without obstructing waterway. In applying the joint compound, care should be taken to place it on the pipe and not the fitting.

All distributing pipes must be straightened before installation, in order to prevent pockets between hangers which would interfere with the proper drainage of the system.

6. **All Portions of Buildings to be Protected.**—Experience teaches that sprinklers are often necessary where seemingly least needed. Their protection is required not alone where a fire may begin, but also wherever any fire might extend, including wet or damp locations.

7. **Degree of Protection.**—A maximum protection cannot be expected where sprinklers are at more or less permanent disadvantage, as in the case of stocks very susceptible to smoke and water damage, buildings having deep piles of hollow goods, excessive draughts, explosion or flash fire hazards, or large amounts of benzine or similar fluid.

8. **Necessary Cut-offs.**—Sprinklers cannot be expected to keep out fire originating in unsprinklered territory. Stringent measures should be used to properly cut off all unsprinklered portions of buildings or exposures.

9. **Communications.**—When a building fully equipped with sprinklers communicates with another not so equipped, the openings must be protected by standard fire doors on both sides of the walls, one of which must be automatic.

10. **Protection Against Exposures.**—The danger of sprinkler protection being impaired by exposure fires should be reduced by providing at exposed openings one or more of the following: Shutters, wired glass or open sprinkler protection.

Section B—Location of Automatic Sprinklers

11. **Position of Sprinkler.**—Shall be located in an upright position.

When construction or occupancy of a room or enclosure makes it preferable, permission may be given, except on dry-pipe systems, to locate sprinklers in a pendant position.

12. **Position of Deflectors.**—Sprinkler deflectors shall be parallel to ceilings, roofs or the incline of stairs, but when installed in the peak of a pitched roof they shall be horizontal. Distance of deflectors from ceilings of mill or other smooth construction, or bottom of joists of open joist construction, shall be not less than 3 inches nor more than 10 inches; 6 to 8 inches is the best distance with average pressure and present types of sprinklers. Note particularly that the rule for distance refers to the deflector of the sprinkler. In the case of fireproof buildings, the distance between deflectors and ceilings may be increased where conditions warrant; i. e., under panel ceilings. In semi-mill or other unusual construction, consult the Inspection Department having jurisdiction.

13. **Detailed Locations.**—Sprinklers shall be placed throughout premises, including basement and lofts, under stairs, inside elevator wells, in belt, cable, pipe, gear and pulley boxes, inside small en-

closures, such as drying and heating boxes, tenter and dry-room enclosures, chutes, conveyor trunks and all cupboards and closets unless they have tops entirely open, and are so located that sprinklers can properly spray therein. Sprinklers are not to be omitted in any room merely because it is damp, wet or of fireproof construction.

Special instructions should be obtained from Inspection Department having jurisdiction relative to placing sprinklers inside show windows, telephone booths, boxed machines, metal air ducts, ventilators and concealed spaces, and under large shelves, benches, tables, overhead storage racks, platforms and similar water-sheds, and over electrical generating and transforming apparatus and switchboards.

14. **Protection of Vertical Shafts.**—In vertical shafts having inflammable sides, a sprinkler shall be provided within shaft for each 200 square feet of the inflammable surface, in addition to sprinklers at tops of shafts. Such sprinklers should be installed at each floor when practicable, and always when shaft is trapped.

Where practicable, sprinklers should be "staggered" at the alternate floor levels, particularly when only one sprinkler is installed at each floor level.

Section C—Spacing of Automatic Sprinklers

15. **Distance from Walls.**—The distance from wall or partition to first sprinkler shall not exceed one half the allowable distance between sprinklers in the same direction. Additional sprinklers may also be required in the narrow pockets formed by bay timbers or beams and wall.

16. **Partitions.**—A line of sprinklers should be run on each side of partition. Cutting holes through a partition to allow sprinklers on one side thereof to distribute water to the other side is not effectual. This rule applies to both solid and slatted partitions.

Editor's Note: See Appendix for Amendment adopted in 1916.

17. **Mill Construction.**—Under mill ceiling (smooth solid plank and timber construction, 5 to 12 foot bays) one line of sprinklers should be placed in center of each bay and distance between the sprinklers on each line should not exceed the following:

8 feet in 12 foot bays.
9 feet in 11 foot bays.
10 feet in 10 foot bays.
11 feet in 9 foot bays.
12 feet in 5 to 8 foot bays

Measurements should be taken from center to center of timbers.

Ceilings of modified mill construction having bays less than three feet should be treated as open joist construction and sprinkler heads spaced accordingly.

Bay timbers spaced three feet or more on centers, but less than five feet on centers, will require special ruling by the Inspection Department having jurisdiction.

18. **Joisted Construction.**—Under open finish joisted construction, ceilings, floors, decks and roofs, the lines shall be run at right angles to the joists and the sprinklers "staggered spaced," so that heads will be opposite a point half way between sprinklers on adjacent lines, and the distance between sprinklers not exceeding

8 feet at right angles to the joists or 10 feet parallel with joists; the end heads on alternate lines being not more than 2 feet from wall or partition.

Also see Rule 15.

Exception.—An exception may be made to this rule if the conditions warrant, viz., special permission may be given to install but one line of sprinklers in bays 10 to 11½ feet wide from center to center of the timbers which support the joists. In all cases where such bays are over 11½ feet wide, two or more lines of sprinklers should be installed in each bay as required by the rules for spacing. This does not apply where beams are flush with the joists, in which case sprinklers may be spaced as called for in Rule 18. Where permission is given, the sprinklers should be placed closer together on a line so that in no case will the area covered by a single sprinkler exceed 80 square feet. Also see Rule 22.

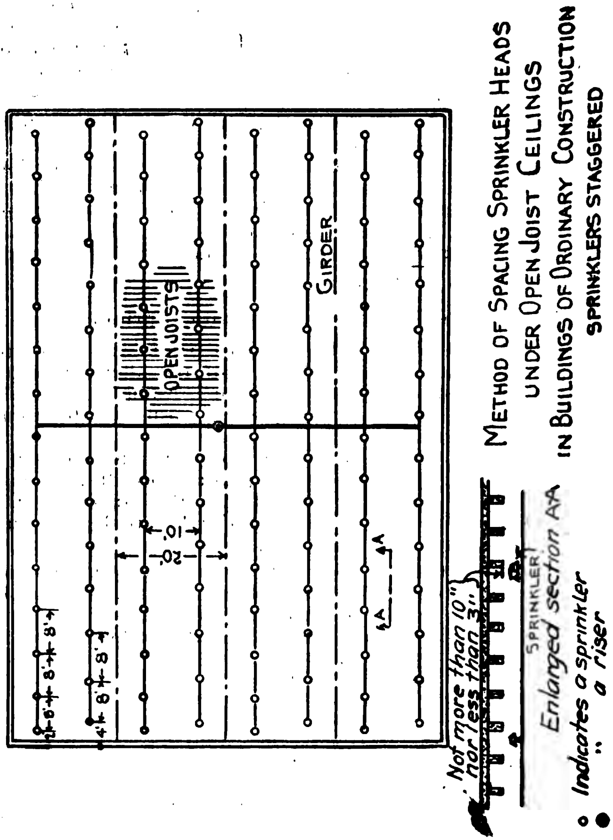
METHOD OF SPACING SPRINKLER HEADS
UNDER OPEN JOIST CEILINGS
IN BUILDINGS OF ORDINARY CONSTRUCTION
SPRINKLERS STAGGERED
GIRDER
OPEN JOISTS
10'
20'
A
A
4' 8' 8' 8'
4' 8' 8'
Not more than 10" nor less than 3"
SPRINKLER
Enlarged section A-A
Indicates a sprinkler
" a riser

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FIG. 80

19. **Smooth Finish, Sheathed or Plastered Ceilings.**—Under smooth finish, sheathed or plastered ceilings, in bays 6 to 12 feet wide (measurement to be taken from center to center of timber, girder or other projection or support, forming the bay), one line of sprinklers shall be placed in center of each bay, and distance between the sprinklers on each line should not exceed the following: 8 feet in 12 foot bays; 9 feet in 11 foot bays; 10 feet in 6 to 10 foot bays. Bays in excess of 12 feet in width and less than 23 feet in width should contain at least two lines of sprinklers; bays 23 feet in width or over should have the lines therein not over 10 feet apart. In bays in excess of 12 feet in width not more than 100 square feet ceiling area should be allotted any one sprinkler.

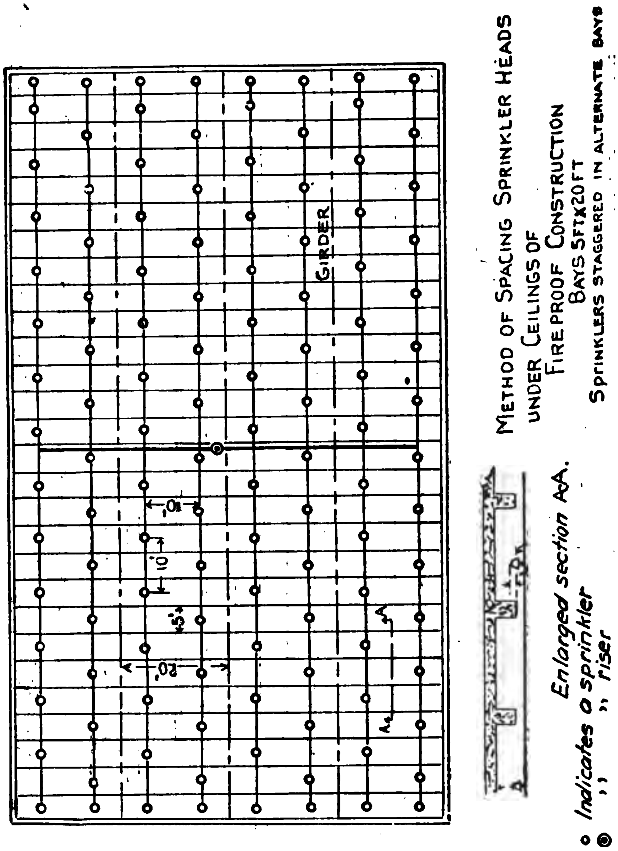

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FIG. 81

20. **Pitched Roofs.**—Under a pitched roof sloping more steeply than 1 foot in 3, sprinklers shall be located in peak of roof, and those on either side of peak spaced according to above requirements Distance between sprinklers should be measured on a line parallel with roof. Where the roof meets the floor line, sprinklers should be placed not over 3½ feet from where roof timbers meet floor.

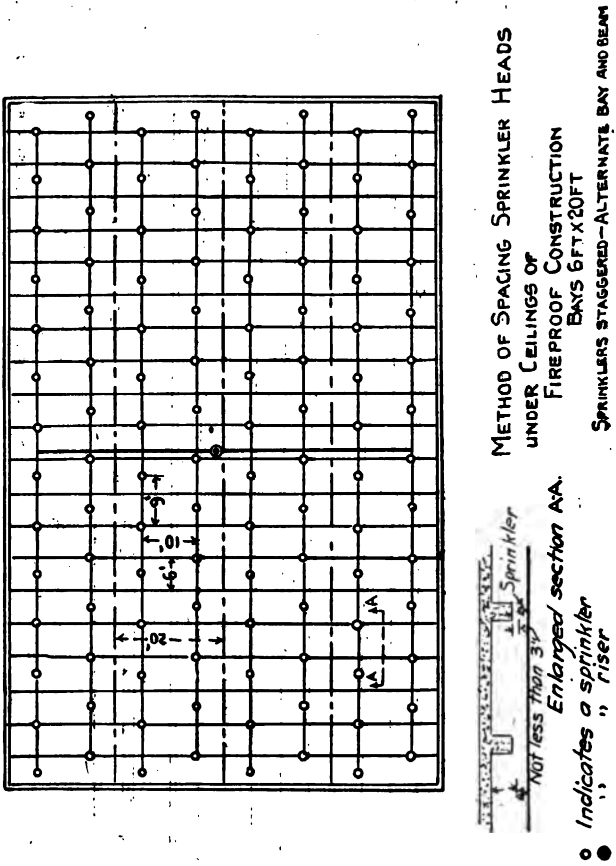
6'
10'
6'
20'
A
A
Sprinkler
Not less than 3"
Enlarged section AA.
○ ● Indicates a sprinkler
" " riser
Method of Spacing Sprinkler Heads under Ceilings of Fireproof Construction
Bays 6 ft x 20 ft
Sprinklers staggered—Alternate bay and beam

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FIG. 82

Sprinklers not more than 2½ feet distant each way from the peak of roof, measured on a line with the roof, may be used in lieu of sprinklers located in peak of roof as above. Also see Rule 22.

In sawtooth roof, the end sprinklers on the branch line shall be not over 2½ feet from the peak of the sawtooth.

21. **Fireproof Construction.**—The rules for slow-burning construction should apply as far as practicable. The rule may be modified, however, the intent being to arrange the spacing of sprinklers to protect the contents rather than the ceilings; but in no case shall the distance of a sprinkler on a line exceed 12 feet to a sprinkler on an adjoining line.

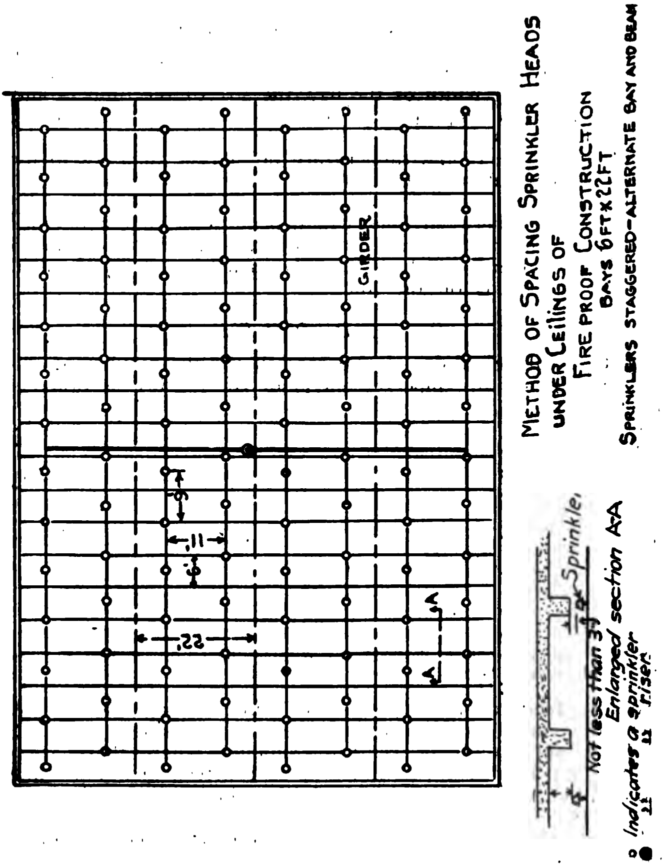
METHOD OF SPACING SPRINKLER HEADS UNDER CEILINGS OF FIRE PROOF CONSTRUCTION
BAYS 6FT×22FT
SPRINKLERS STAGGERED—ALTERNATE BAY AND BEAM

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FIG. 83

22. **Unusual Construction.**—Special instructions should be obtained from Inspection Department having jurisdiction relative to location of sprinklers under floors and roofs of semi-mill, panel or other unusual construction which may interfere with distribution of water, and for which provision is not hereinbefore made.

These types of construction are so varied that no absolute rules can be given to cover all cases.

"Semi-mill" is the term here applied to plank and timber construction with narrow bays generally less than 5 feet in width.

"Panel" construction is where the ceiling is divided by the timbers into panels or pockets. Narrow bay panels come under the head of "semi-mill" construction, and may usually be protected in the same way.

Sprinkler lines should usually run at right angles to the timbers, with heads staggered under alternate timbers, in alternate bays, or alternately under the timbers and in the bays, the arrangement depending on the width of the bay, the size of the timbers and the distance between supporting girders, as well as upon the occupancy and water pressure.

Ordinarily, where the timbers are not larger than 6 x 10 inches, the best distribution is obtained by placing the heads under the timbers.

The distance between lines will depend somewhat upon the distance between the girders supporting the timbers, the number of lines in these transverse bays being governed largely by the distance between the heads on the lines.

Section D—Pipe Sizes

23. **General Schedule.**—In no case should the number of sprinklers on a given size pipe on one floor of one fire section exceed the following:

Size of Pipe.	Maximum No. of Sprinklers Allowed.
¾-inch	1 sprinkler
1 "	2 sprinklers
1¼ "	3 "
1½ "	5 "
2 "	10 "
2½ "	20 "
3 "	36 "
3½ "	55 "
4 "	80 "
5 "	140 "
6 "	200 "

Where practicable, it is desirable to arrange the piping so that the number of sprinklers on a branch line will not exceed eight.

Where feed mains supply branch lines of only two sprinklers each, the conditions approach those of long single lines. Such feeds should usually be centrally supplied where there are over eight or ten branch lines. Lines up to fourteen in number may be fed from end, provided 2½-inch pipe supplies not more than sixteen sprinklers.

Buildings having slatted floors, or large unprotected floor openings without approved stops, should be treated as one room with reference to the pipe sizes, and the feed main should be of sufficient size to accommodate the number of sprinklers called for. Larger pipe sizes than called for in the schedule may be required wherever the construction or conditions introduce unusually long runs of pipe or many angles. Buildings with blind attics with small unprotected openings to floor below, may be piped from the system on the ceiling of floor below, provided pipe size schedule is not overloaded on sizes 3 inches or under.

Section E—Feed Mains and Risers

24. **Location of Risers.**—"Center central" or "side central" feed to sprinklers is recommended. The former is preferred, especially where there are over six sprinklers on a branch line. In high buildings, allowance must be made for frictional loss and sizes of risers increased accordingly. Risers should not be located close to windows, and should be properly protected from mechanical injury or a possible freezing.

25. **Supporting of Risers.**—Risers should be properly supported. In buildings of heavy construction and where riser is not supported at the ground level, floor plates or clamps and pipe couplings should be provided at the first (ground) floor level, and also at every fourth floor above same, where a building is over five stories in height, except that in buildings nine to ten stories high no floor plate nor coupling would be needed above the fifth floor.

This would call for such supports at the first (ground) and fifth floors in a building seven to ten stories high, and floor plates and couplings at the first (ground), fifth and ninth floors in buildings eleven to fourteen stories high, etc. In buildings of light construction, additional supports will be needed.

Where risers are supported at the ground level, provide such supports at every fourth floor above same. (See Appendix for modification made in 1916.)

Where sprinkler risers, or those from tanks, are in vertical shafts, they should be supported equivalent to the above.

Where risers, drains, heating pipes, etc., pass through cinder concrete, a sleeve or other suitable means should be provided to prevent corrosion. Neat cement or seven per cent lime mortar around the pipe will protect same.

26. **Size of Risers.**—There should be one or more separate risers in each building and in each section of the building divided by fire walls. Each riser should be of sufficient size to supply all the sprinklers on said riser on any one floor, as determined by the standard schedule of pipe sizes. If the conditions warrant, special permission will be granted allowing the sprinklers in a fire section of small area (total number of sprinklers not to exceed 48 per floor) to be fed from the riser in another section.

Stair or other towers without approved stops between floors, if piped on independent riser, should be treated as one room with reference to pipe sizes, i. e., feed main should be of sufficient size to accommodate the total number of sprinklers.

27. **Connections to Systems.**—All main water supplies should connect with sprinkler system at foot of riser.

Exception.—Where a gravity or pressure tank or both, constitute the only automatic source of water supply, special permission may be given to connect the tank or tanks with the sprinkler system at the top of the riser, provided lower level control to several fire sections is not required.

The connection between the wrought iron or steel and cast iron pipe from underground main should preferably be flange and spigot pipe properly strapped together.

Where bell and spigot pipe is used, the wrought iron or steel and cast iron pipes should be properly strapped together. A flanged connection should be used on the wrought iron or steel pipe and not simply clamps with set-screws. For 8-inch pipes and smaller, the rod to be ⅝ inch, for larger pipe, ¾ inch. Straps or rods, if to be buried, should be protected against corrosion by painting with tar, asphaltum, or by other suitable means. Where practicable, connections should run underground to the foot of the riser; but in any event, the cast-iron pipe should extend above ground, and no cinders or other corrosive material should be placed against either pipe. See Rule 28.

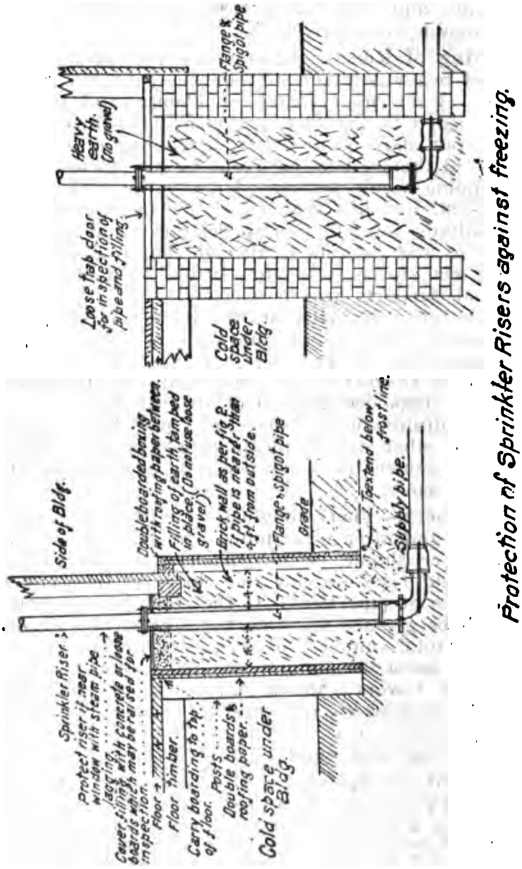
Flange & Spigot pipe
Heavy earth. (No gravel)
Loose trap door for inspection of pipe and filling.
Cold space under Bldg.
Side of Bldg.
Double boarded boxing with roofing paper between.
Filling of earth tamped in place. (Do not use loose gravel)
Brick wall as per fig. 2. If pipe is nearer than 4 ft. from outside.
Flange & spigot pipe
Grade
Extend below frost line.
Supply pipe.
Sprinkler Riser
Protect riser if near window with steam pipe lagging
Cover filling with concrete or loose boards which may be raised for inspection.
Floor
Floor timber.
Carry boarding to top of floor.
Posts
Double boards & roofing paper.
Cold space under Bldg.
Protection of Sprinkler Risers against freezing.

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FIG. 84

28. **Protection Against Frost.**—(See Figure 84.) Where supply pipes or risers in low basements or low spaces under ground floors are exposed to frost, they should be properly protected. An acceptable method, especially where the space is over 18 inches high, is by an enclosure properly heated or filled with heavy earth or other suitable material, such as mineral wool or sawdust. Enclosure

should extend below bottom of pipe and through the top flooring of ground floor. In severe climates, where space is filled, the enclosure should be of sufficient size to permit of a filling of not less than four (4) feet, all sides around the pipe. Enclosure should preferably be of brick, but may be of wood, and if the latter, should be at least double with tar paper between. Where the space is not more than 18 inches high, the flooring of ground floor may be cut away and the space around the pipe enclosed according to either of the above methods, but the area may be reduced so there will be not less than one (1) foot clear space all sides around the pipe, thus exposing pipe to the heated room above. Opening at floor level should not be covered except by a metal grid.

In any case where wood is used, it should be of a kind that will endure underground, and in addition, should be treated with creosote or other acceptable preservative.

Care should be taken in laying the underground connection, to extend it sufficiently far into the building to give the required spaces called for above, the pipe to be offset if desired, at or above the floor level.

The laying of connections in raceways exposed to frost should be avoided, owing to the difficulty of protecting the pipe near the surface and in the space between the surface of the water and the floor of the building. Such connections, if they cannot be avoided, should go through the wall of the race below the frost line, and enter the building through the solid ground, and far enough back from the side of the race to avoid frost.

Section F—Valves and Fittings

29. **Types of Valves to be Used.**—All valves on connections to water supplies and in supply pipes to sprinklers should be standard outside screw and yoke or other standard indicator pattern.

Underground gate valves of standard pattern equipped with standard indicator posts fulfill this rule.

Drip and/or test pipes should be of a standard type.

Check valves should be of a standard straight-way pattern, and installed in horizontal pipe, unless suitably designed for vertical position.

30. **Valves in Connection to Water Supply.**—The pipe connecting each source of water supply with the sprinkler system shall be provided with a gate and a check valve. The gate valve should be located close to the supply, as at the tank, or near base of tank trestle, pump, or in the pipe connecting the riser with the waterworks system, and the check valve should be located as far as possible from source of supply, preferably underground.

Check valves on public water connections and large tanks or reservoirs should have a gate valve on each side so that check may be repaired without shutting off the water supplies.

NOTE.—The underground waterworks valve on the waterworks connection may be considered satisfactory for one of these valves.

For tanks on trestles a post indicator valve at foot of trestle is recommended. Where near tank, should be made readily accessible by permanent ladder and platform.

31. **Check or Gate Valve on Pump or Tank Discharge.**—When a pump, not located in a non-combustible pump house, or exposed to danger from fire or falling walls, or a tank discharges into a

yard main fed by another supply, a check valve or post gate valve should be placed in this discharge pipe at a safe distance outside the building, underground.

Check valves on tank connections may be placed inside buildings, when located underground and at a safe distance from the tank riser.

32. **Valves in Supply Pipes to Sprinklers.**—Each system shall be provided with a gate valve so located as to control all sources of water supply except that from steamer connections. All gate valves controlling water supplies for sprinklers should be located where readily accessible.

Inspection Department having jurisdiction should be consulted regarding floor equipment valves.

Where valves are not within easy access from ground or floor level, permanent ladders, clamped treads on risers, chains and wheels, or other means satisfactory to the Inspection Department having jurisdiction, should be provided.

33. **Indicator Posts for Gate Valves.**—Where sprinklers are supplied from yard main, place, if possible, a standard outside post indicator gate valve in connecting pipe at safe distance from building.

Post indicator valves should, if possible, be located not less than 40 feet from buildings; but where necessary to place a valve close to a building, it should be located between windows or at a blank part of wall.

34. **Pit for Underground Check Valves.**—Where not in pits, the location should be properly marked by some permanent marking. Where in pits, the pit should conform to the National Fire Protection Association standard, and should be of ample size to permit of easy access to the valve for examination and repairs.

35. **Straps.**—All gate valves in supply pipes to automatic sprinklers, whether or not of indicator or post pattern, should be kept secured open with padlocked or riveted leather straps. An exception to this rule may be made only where a reliable system is maintained for permanently sealing all valves and for immediate notification of broken seals.

No sealing or strapping is required where sprinkler system has a supervisory system to the approval of the Inspection Department having jurisdiction.

36. **Fittings.**—Extra heavy fittings should be employed where the normal pressure in the pipe system exceeds one hundred and fifty pounds.

All fittings and pipes shall have threads cut to standard, and care should be taken that the pipe does not extend into fitting sufficiently to reduce the waterway.

Long turn fittings will be required for 2½ inches and larger risers and supply mains, the fittings to be flanged on at least one end.

Couplings.—Couplings shall not be used except where it is practically unavoidable.

The use of any considerable number of couplings in an equipment is considered as prima facie evidence of poor workmanship.

Reducers.—A one-piece reducing fitting of good design shall be used wherever a change is made in the size of pipe. Bushings shall not be used for reducing the size of the openings of fittings.

37. **Hangers.**—Hangers shall be of an approved type and either round wrought-iron "U" (factory made and bent hot), malleable cast-iron ring clip or other adjustable patterns.

Wrought-iron hangers are preferable to cast iron, and "U" hangers are for this reason best where their use is possible.

Flat-iron "U" hangers may be accepted, provided the thickness of the metal be in no case less than 3/16 inch, and of sufficient width to allow plenty of metal each side of the screw holes.

Screws and Rods.—Wood screws for adjustable clip hangers should not be smaller than No. 17, and must penetrate ceiling beam or joist at least 1¼ inches. For 2-inch pipes and smaller two screws should be used, and for larger pipes four screws should be used.

The size of rod and screws for hangers should be as given in the following tables:

Size of Pipe	Size of U Rod	Size of Single Rod if Threaded	Size of Drive Screws	Size of Coach Screws
¾" to 2"	5/16"	⅜"	No. 16 x 2"	
2½"	⅜"	½"		⅜ x 2½"
3"	⅜"	½"		⅜ x 2½"
3½"	7/16"	½"		⅜ x 2½"
4"	7/16"	⅝"		½ x 3"
5"	9/16"	⅝"		½ x 3"
6"	⅝"	¾"		½ x 3"
8"	¾"	⅞"		⅝ x 3"

Drive screws should be used only in a horizontal position as in the side of a beam.

Screws in the side of a timber or joist should not be less than 2½ inches from the lower edge, when supporting branch lines. A greater distance is desirable for larger pipes.

Position of Hangers.—Hangers should not be near enough to sprinklers to obstruct distribution of water. Ordinarily, they should not be nearer than 12 inches from sprinkler, except in the case of round iron hangers where a space of not less than 3 inches may be permitted under ceilings of "fire-proof" and "slow-burning" construction.

The ¾-inch pipe at the end of all branch lines when over 6 feet in length shall have two hangers.

For concrete construction: The cast-iron inserts should be installed during the construction of the building, or provision made for attaching the hangers to the beams. If in buildings already constructed expansion bolts are used, they should be of a type satisfactory to the Inspection Department having jurisdiction and if possible installed in a horizontal position.

For new concrete buildings, the location of sprinkler pipes and hangers shall be determined previous to building operations, in order that proper provision may be made during the construction for the installation.

Where pipes are run through concrete beams, the sleeves should be large enough to accommodate pipe at least two sizes larger than it is intended to install.

38. **Drip Pipes.**—Drip pipes shall be provided to drain all parts of the system. Drip pipes at the main risers should be not smaller than two (2) inches, and when exposed to the weather to be fitted with hood or down-turned elbow to prevent stoppage with ice.

Drip pipes shall be so arranged as not to expose any part of the sprinkler system to frost, and so connected, either by check valves or other means, that they will not overflow domestic service or other connections there may be to the same sewer or drain.

Drips for small sections shut off in winter shall be located in a warm room or below frost, so as to drain all portions of pipe where freezing can occur.

Drain, drip or draw-off pipes shall not terminate in blind spaces under the buildings. The water from these washes the soil away, exposing the supply pipe and may undermine the structure protecting the pipe.

Cold air enters draw-off pipes and may cause freezing of the valves.

All drips should have at least 4 feet of pipe exposed in the warm room.

See also Section G, Alarm System.

39. **Drainage.**—All sprinkler pipe and fittings shall be so installed that they can be thoroughly drained, and, where practicable, all piping should be arranged to drain at the main drips. On wet-pipe systems the horizontal branch pipes shall be pitched not less than ¼ inch in 10 feet. (See also Section H, Rule 49.)

In wet systems ¾-inch composition plugs may be allowed where a few low heads are involved, as under stairways. Limit the extra drips to as small a number as possible.

40. **Test Pipes.**—Alarm.—On wet systems a test pipe of not less than ¾-inch in diameter shall be connected directly with each riser in upper story and arranged to discharge, through a ½-inch brass outlet, preferably to a point where it can readily be seen. With long runs or many angles, size of test pipe should be increased to 1 inch or larger.

Water Flowing.—It is very essential that either drains or test pipes should be provided so that proper flowing tests may be made to determine if the water supplies and/or the connections from yard mains to inside of buildings are in order. Any such drain or test pipe should be not less than 2 inches in size, and so installed that the controlling valves may be opened wide for a sufficient time to assure a proper test without overflowing any service connections there may be to the same drain, or cause any water damage. A pressure gauge should be installed in each case, connection for it should not be less than ¼ inch in size, controlled by a valve with arrangements for draining, and located on the main pipe and not on the drain or test pipe. On a wet system, where the controlling valves and drains may be located in a detached pit or valve house, test pipes should be provided inside of the buildings on the various connections to the sprinkler system. The Inspection Department having jurisdiction should determine the method to be used in each case. See illustrations for various types of test pipes, and also Rule 41.

Dry-pipe Systems.—See Section H, **Rule** 50.

41. **Pressure Gauges.**—A standard make, 5-inch dial, spring, pressure gauge should be connected with the discharge pipe from each water supply, including each connecting pipe from public waterworks, and also as follows:

In each sprinkler system above and below the alarm check or dry-pipe valve.

At the air pump supplying the pressure tank.

At the pressure tank.

In each independent pipe from air supply to dry-pipe systems.

At test pipes as above, Rule 40.

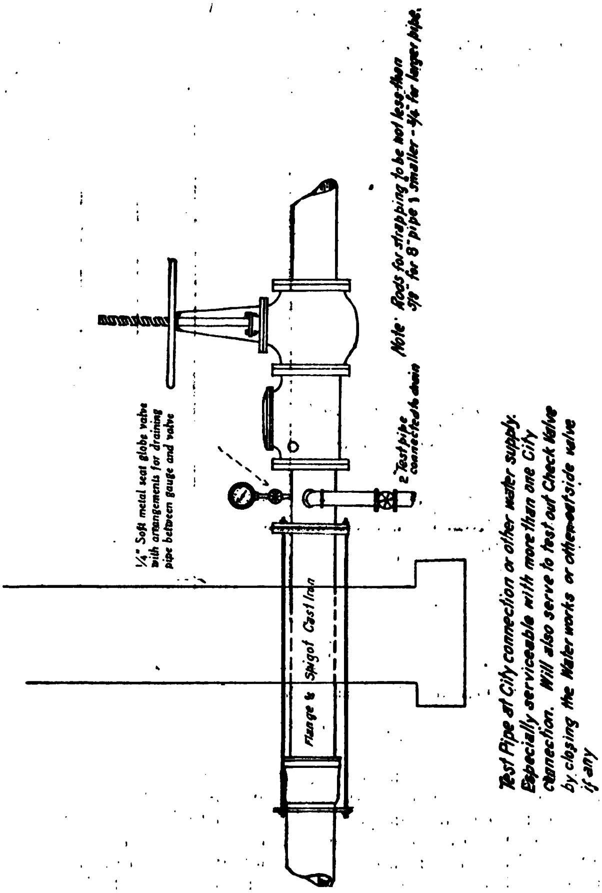
Note: Rods for strapping to be not less than 5/8" for 8" pipe 1 smaller - 3/4" for larger pipe.
2" Test pipe connected to drain
1/4" Soft metal seat globe valve with arrangements for draining pipe between gauge and valve
Flange & Spigot Cast Iron
Test Pipe at City connection or other water supply. Especially serviceable with more than one City connection. Will also serve to test out Check Valve by closing the Water works or otherwise side valve if any

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FIG. 85

Gauges shall have a maximum limit equivalent to twice the normal working pressure where installed. Should also be connected direct with riser, but with sufficient clearance to permit of easy removal, connection being tapped into drain tee, preferably opposite the drainpipe, but not on drainpipe. Gauges should be located in a suitable place and where water will not freeze. Each should be controlled by a valve with arrangement to drain. A plugged outlet should be located between each valve and gauge, for the purpose of installing the inspector's gauge, size to be not less than as noted in Rule 40.

Section G—Alarm System

42. **Gongs and Connections.**—Every automatic sprinkler system should contain an alarm apparatus so constructed that a flow of water through same will operate an electric gong, a mechanical gong, or both, as the character of the property and circumstances may require. On wet-pipe systems, or partially so, this apparatus should consist of an alarm valve and attachments; on dry-pipe systems, attachments to dry-pipe valve (see Section H), except that where there is an approved supervisory system to a central station, one of the local alarms may be omitted at the discretion of the Inspection Department having jurisdiction. In other places, especially in small towns, alarm valve or dry-pipe valve may be connected with public fire department house, or some other suitable place.

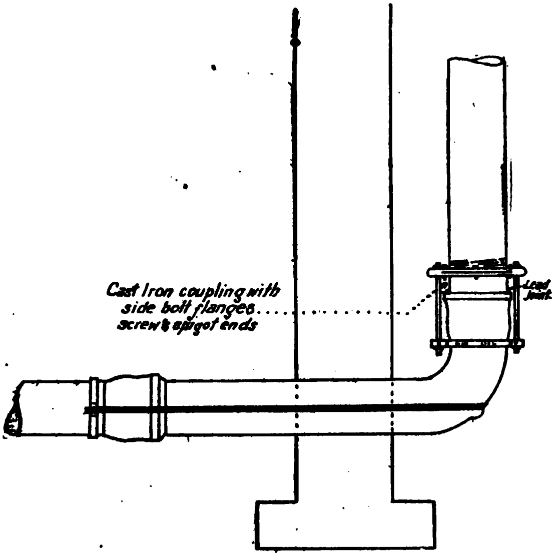

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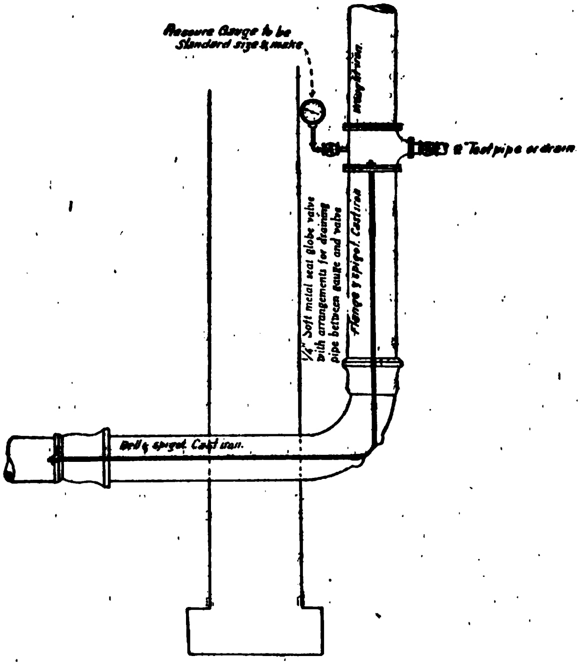
FIG. 86

The use of both electric and mechanical gongs is strongly recommended. The gong of the latter type can be located on the outside of building or any other desirable place on the premises. When located on the outside, all gongs shall be protected from the weather. Electric bells shall be of standard type.

Rotary gong should be located as near alarm valve or dry-pipe valve as possible. Attention is called to the necessity of avoiding long runs or many angles in pipe to rotary gong. The total length of pipe horizontally should not exceed 75 feet, and vertically 20 feet.

All pipe between alarm valve, dry-pipe valve and rotary gong should be galvanized or brass of a size not less than ¾ inch, and larger for long runs of piping or where pressures are low; and arranged to drain properly through not larger than a ⅛-inch orifice, brass bushed.


Pressure Gauge to be Standard size & make
Wrought iron.
2" Test pipe or drain
1/4" Soft metal seat globe valve with arrangements for draining pipe between gauge and valve
Flange & spigot. Cast iron
Bell & spigot. Cast iron.

Test pipe where there is outside control.
Also applicable to any other interior riser.

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FIG. 87

Water motor and gong should be properly aligned and so installed as not to be liable to get out of adjustment.

The drain from the water motor should be properly connected. See Rules 38, 40 and 47.

43. **Alarm Apparatus.**—Shall be so located that the passing of water through any of the automatic sources of supply to any of the sprinklers will cause its action.

44. **Approval.**—Alarm valve or other alarm apparatus should be approved by the Inspection Department having jurisdiction.

45. **Wiring and Energy for Electric Alarms.**—Should be installed in accordance with the rules of the National Board of Fire Underwriters. (See Signaling Systems.)

46. **Alarm Valve Installation.**—The alarm valve, retarding chamber and circuit closer shall be so located that all parts will be readily accessible for inspection, repair or removal, and all shall be substantially supported. Suitable valves shall be provided in the connections to the retarding chamber to permit repair or removal without shutting off sprinkler system. These valves should be arranged to be readily secured open.

47. **Drains.**—A vent should be provided for circuit closer. Where used, should be properly piped to a drain.

Drains at alarm valve and at the variable pressure chamber, circuit closer and rotary gong connected with valve, shall be so arranged that there will be no danger of freezing, and also so protected, by checks or otherwise, that there will be no overflowing at the alarm apparatus or of domestic connections that may be on the same drain, with the sprinkler drains wide open. Where checks are used, they should have the equivalent of at least a four foot head, and not installed in a vertical position "looking down."

Drains from retarding chamber and circuit closer should discharge either to open cones connected as above, or the drain from alarm valve run separate from the other drains to the sewer or ground drain, a union or plug being inserted in each drain to permit of inspection.

Where drains are connected with a sewer, proper trap shall be provided.

Cold air has been known to enter drainpipes from retarding chambers of alarm valves sufficiently to cause trouble by freezing in the alarm check valve. Where exposed to frost and it is necessary to drain alarm valves outside the wall, an open discharge cone should be provided inside to break the pipe line so cold will not be conducted directly into the retarding chamber. (See Section F, Rule 38.)

Section H—Dry-Pipe System and Fittings

48. **Where Necessary.**—A dry-pipe system should be required only where a wet-pipe system is impracticable, as in rooms or buildings which cannot be properly heated by the exercise of reasonable precaution. The use of an approved dry-pipe system is, however, far preferable to entirely shutting off the water supply during cold weather.

Where it is necessary to have but twenty-five (25) per cent or less of the total number of sprinklers on an air system, only such sprinklers should be thus piped; the remainder to be placed on wet system.

This rule requires small dry-pipe systems for show windows, blind attics or other minor portions exposed to freezing.

Air pressure should be maintained on dry-pipe systems throughout the year, unless changed by consent of the Inspection Department having jurisdiction.

(See also Section K, Rule 77.)

49. **Drainage.**—Sprinklers shall be located in an upright position. All sprinkler pipes and fittings shall be so installed that they can be thoroughly drained and, where practicable, all pipes should be arranged to drain at the main drip, ordinarily located at the dry-pipe valve. The tops of branch lines should pitch at least ½ inch in 10 feet, and more where settling may occur. A pitch of ¾ inch to 1 inch is usually not impracticable with short branch lines, and should be provided where there is a chance of settling.

Where settling may occur and deprive a dry-pipe system of its drainage, the ends of lines should not be raised to violate Section B, Rule 13. The drainage should be restored by shortening the vertical piping.

Extra Drips.—When conditions are such that additional drip valves are necessary, such as under stairs, low platforms, etc., these should be conveniently located, so that they may be accessible for inspection and test. Drip valves should have soft metal seats and composition plugs.

Connection from Top of Pipe.—Where the supply for these low sprinklers is taken from a large pipe, such as a trunk main, the connection should be made from or near the top of the large pipe, so as to prevent condensation in same entering the small pipe. This can be accomplished by looping back the connection. Where feasible, the drains for these low portions should be carried back into warm rooms, and the drip valves located there.

½-inch Test Pipe.—In cold climates, where there may be a considerable number of sprinklers or a low point in large pipe drained by a separate drip, requiring a drain valve 1¼ inch or more in size, it is advisable to provide either a condensation drip or a ½-inch drip valve back of and below the larger drain valve. This latter arrangement will permit the blowing out of these low pipes through the ½-inch valve, when there might be danger of upsetting the system by opening the larger drain.

Care should be taken to support the piping in a secure manner, and to see that the sprinklers do not violate the rules for position. (See Section B, Rule 12.)

50. **Supply and Test Pipe.**—All water supplies to sprinklers shall enter the system below the dry-pipe valve, shall be properly protected from freezing, and provided with a 2-inch test pipe placed directly under the dry-pipe valve. Test pipe should be provided with a standard valve and be properly connected to a drain, so as to permit of the valve being opened wide for a water flowing test. Pressure gauges should also be provided as called for in Section F, Rule 41.

51. **Size of Dry System.**—The number of sprinklers dependent upon one dry-pipe valve should preferably not exceed 300, and 400 heads should be the maximum allowed, except in very special cases.

If there is a considerable length of pipe between the dry-pipe valve and the sprinklers, thus materially increasing the air capacity of the system, the number of heads equivalent to this additional capacity, based on one head per gallon contents of this pipe, should be considered when estimating the total number of sprinklers.

Where more than 400 sprinklers are necessary in buildings containing two or more floors, the system preferably should be divided horizontally by consecutive floors and supplied through two or more dry-pipe valves. It will be allowable, however, where this rule would necessitate increase in the number or size of the dry-pipe valves, or involve a complication of the piping to provide for vertical sub-division.

Sub-division of System.—A dry-pipe system may be still further sub-divided by the insertion of check valves in the different branches of the system, thus quickening the operation of the dry-pipe valve. Holes ⅛ inch in diameter should be bored in the clappers of the checks to equalize the air pressure under normal conditions, and a drain, properly connected, should be provided in front of each check valve.

The dry-pipe valve should be located in an accessible place and as near as practicable to the sprinkler system it supplies.

Dry-pipe Underground.—When it is necessary to place pipe which will be under air pressure underground, it is desirable that it be buried below frost, so as to prevent any trouble from the heaving action of frozen ground. This pipe should be wrought iron or steel, and have at least two coats of some good rust-proof paint, such as asphaltum, tar, etc., one coat to be applied before the pipe is laid, and the other after all joints are made up, final turn.

No lead-jointed, cast-iron pipe shall be used under air pressure, and all pipe liable to corrosion, where underground or exposed to chemical fumes, for example, shall be painted or otherwise so treated as to reduce to a minimum this deterioration, which, with the pipes unprotected, might soon cripple the system. To further safeguard the piping against corrosion, it is advised that after the joints are made up and before the second coat of paint is applied, the pipe should be wrapped tightly with burlap and burlap painted on outside; also that the pipe should be laid in a box or split tile conduit for still additional protection.

Pressure to be Carried.—High air pressure in dry-pipe systems is undesirable, and 35 pounds has been found to be the maximum which it is necessary to carry in most cases. Under these conditions, to avoid pumping oftener than once a week, the system should not lose more than about 10 pounds air pressure per week, and an equipment which leaks more than this cannot be considered acceptable. (See also Section K, Rule 77.)

52. **Alarm Attachments.**—Where a dry-pipe valve is not located on the system side of an alarm valve, it should be provided with both mechanical and electrical alarms, installed in accordance with the requirements for alarm valves (Section G). Dry-pipe valve should be fitted with an approved alarm-testing device, this to be connected with water supply so that alarms can be tested without disturbing main gates or air system.

Pressure gauges should be provided as called for in Section F, Rule 41.

53. **Protection of Dry-pipe Valve.**—Dry-pipe valve in any location should be properly protected from mechanical injury.

Where exposed to cold, the dry-pipe valve should be located in an approved underground pit, or in a valve room or closet. Room should be of sufficient size to give at least 2½ feet free space on all sides of, and above or below dry-pipe valve or valves, and this room, if feasible, should not be built until the valve is in position. Valve room should be well lighted, preferably by electric light, and properly heated by steam, electric heater (installation to comply with the National Electric Code), gas or lard oil lantern. If fire heat is used, some ventilation will be necessary to supply the air for combustion.

Valve room should preferably be of fireproof construction, and in exposed locations the walls should be double with 2-inch air space. If the valve room is of wood, it should have double walled top, sides and bottom, with 4-inch hollow space. Space may be filled with tan-bark, mineral wool, etc., as desired. Where lantern or other fire heat is used in wooden valve rooms, all inside woodwork should be thoroughly tinned. The room should also be constructed so that it can be kept reasonably dry. This will call for a means of ventilation to prevent condensation where the climatic conditions are severe. One or more sprinklers, depending upon size of room, should be installed, wet pipe, and controlled by a valve.

54. **Independent Air Filling Connection.**—The connection from the air pump should enter the system in the main riser above the dry-pipe valve, and on this supply at this point a shut-off valve with soft metal seat should be placed, and immediately back of it a check valve.

See Appendix for rule on Anti-Columning pipes.

55. **Air Compressor.**—Pump should be of sufficient capacity to increase air pressure at an average rate of not less than one pound per two minutes pumping (preferably faster).

A relief valve should be provided on every system.

A direct steam or electrically driven air pump is preferred to a power pump. The air supply should be taken from outside or from a room having dry air, in order to avoid carrying moisture into the system. The intake should be protected by a screen.

In extensive systems subject to extreme cold, the air supply should be taken from the room where the lowest temperature and driest air prevail, and drawn through a reservoir or tank of about thirty gallons' capacity containing from ten to fifteen pounds of granulated calcium chloride.

56. **Flanged Dummy.**—A flanged section of pipe, with drain outlet same size as on dry-pipe valve, to take the place of dry-pipe valve, in case of repairs, should be provided for each type and size installed, and kept at the valve.

Section I—Water Supplies

57. **Double Supply.**—For a standard equipment two independent supplies are required. At least one of the supplies should be automatic and one capable of furnishing water under heavy pressure. The choice of water supplies for each equipment should be determined by the Inspection Department having jurisdiction.

58. **Public Water** (except high pressure systems; also applicable to private reservoir and standpipe systems).—One or more connections from a reliable public water system of good pressure and adequate capacity furnishes an ideal "primary supply." A high static water pressure should not, however, be a criterion by which the efficiency of the supply is determined. The supply should give not less than 25 pounds static pressure at all hours of the day at highest line of sprinklers, and also be satisfactory to the Inspection Department having jurisdiction in its ability to maintain 10 pounds pressure at highest sprinklers, with the water flowing

through the number of sprinklers judged liable to be opened by a fire at any one time. Street mains should be of ample size, in no case smaller than 6 inches. Dead end mains should be avoided if possible by arranging main to be fed both ways. No pressure regulating valve should be used in water supply for sprinklers, except by special permission of Inspection Department having jurisdiction, and where meters are used they should be of a standard type.

Where connections are made from public waterworks systems, it is often desirable to have double check valves. Only check valves of special design and standardized for this purpose should be used.

See also Section E, Rule 27.

Connections to public waterworks systems should, where feasible, be controlled by post indicator valves of a standard type and located not less than 40 feet from the buildings protected; or, if this cannot be done, placed where they will be readily accessible in case of fire and not liable to injury. See Rules 27, 28, 30, 32, 33, 97 and 98. Where post indicator valves cannot readily be used, as in a city block, underground gates should conform to the above as far as possible and their locations and direction to open be plainly marked on the buildings.

Connections for domestic or standpipe use over 2 inches in size should conform to the above.

All post indicator valves should be plainly marked with the service they control.

For the construction and installation of the following devices, see elsewhere in this book, or the special pamphlets issued by the National Board of Fire Underwriters:—

Steam Fire Pumps.
Rotary Fire Pumps.
Centrifugal Fire Pumps.
Gravity and Pressure Tanks.

59. **Pumps.**—A well-located fire pump is, under most conditions, the most satisfactory source of the "secondary supply," as with ample water supply it is capable of maintaining a high pressure over a long period of time.

The capacity of the pumping plant, the kind of pump and its source of water supply, should be determined by conditions, and should be the subject of special consideration in each case by the Inspection Department having jurisdiction. The capacity of pump should never be less than 500 gallons per minute when it supplies sprinklers only, and not less than 750 gallons when it supplies hydrants also.

60. **Tanks.** Gravity.—The capacity and elevation should be determined by the Inspection Department having jurisdiction; but where a tank is also drawn upon for hose streams it should not be of less than 30,000 gallons capacity, and should preferably be installed with the bottom not less than 75 feet above the yard level. In any case the bottom of the tank should be at least 20 feet above the highest sprinklers.

Tanks. Pressure.—Capacity of tank should be specified by the Inspection Department having jurisdiction, but should be not less than 4,500 gallons total capacity, except by special permission, and tank should not be located below the upper story of building, and be used as a supply to automatic sprinklers and hand hose only. (See Section K, Rule 75)

61. **Penstocks or Flumes.**—Where connections are made from these, either as a direct supply to automatic sprinklers or as a suction for fire pumps, they should be arranged to avoid mud and sediment. Connections should also be provided with removable screens installed to the requirements of the Inspection Department having jurisdiction. Where connections are made from rivers or lakes they should be provided with removable screens similar to those for pump suction.

62. **Size of Connection.**—Connection from water supply or main pipe system to sprinkler riser should be equal to or larger in size than the riser. Connections for domestic use should not be taken from the fire system. See also Section E, Rule 27, and Underground Pipes, Section M.

Section J—Steamer Connections

63. **Recommendations.**—In addition to the above required double supply, it is recommended that a hose inlet pipe to sprinkler system be provided for connection from hose or steamer of public fire department.

64. **Pipe Size.**—Should be not less than four inches in size except by special consent of Inspection Department having jurisdiction, and fitted with a straightway check valve, but not with a gate valve. Siamese connections should be provided with check valves in the "Y."

Connections should be so located as to provide for prompt and easy attachment of hose.

65. **Drain and Dirt Pocket.**—Each connection should be arranged to properly drain the piping between the check valve and the outside hose coupling, and also to prevent entry of foreign matter, by installing a refuse collector or dirt pocket, and a 1-inch ball type of drip.

66. **Where Attached.**—To equipments having a single riser attach on the system side of the gate valve in the riser if a wet system, but on the supply side of the dry valve if a dry system.

To equipments having two or more risers attach on the supply side of the gate valves, so that with any one riser shut off the supply will feed all the remaining sprinklers.

Any underground pipe used to attach steamer connections to system should be cast iron, and the wrought and cast iron pipes should be properly strapped together.

All steamer connections should be so arranged that they have proper support.

67. **Threads.**—Each hose connection should be made of good brass, having thread to fit coupling of public fire department. Standard cast iron, malleable iron or brass caps, properly secured, and arranged for easy removal by public fire department, should be provided in each connection.

Each hose connection should be designated by raised letters at least 1 inch in size, cast in the fitting in a clear and prominent manner and reading: "Auto. spkr."

68. **Number of Connections.**—Should be specified by the Inspection Department having jurisdiction in each case.

Section K—Miscellaneous Rules

69. **Circulation in Pipes.**—Circulation of water in sprinkler pipes is very objectionable, owing to greatly increased corrosion, deposit of sediment and condensation drip from pipes; sprinkler pipes not to be used in any way for domestic service.

70. **Painting, Whitewashing or Bronzing.**—Where pipes are painted, whitewashed or bronzed for appearance, the moving parts of sprinkler heads should not be so coated.

71. **Protection of Pipes and Sprinklers Against Corrosion.**—In places where chemical fumes or much moisture is present, sprinkler pipes, hangers and heads should be protected against corrosion, method to be determined by the Inspection Department having jurisdiction; but the following are recommended:

Protection of Pipes.—Where subject to corrosive influences, sprinkler piping and fittings should be thoroughly protected.

In some places it will be satisfactory to paint annually with red lead and linseed oil paint, this usually giving sufficient protection when exposed to moisture only.

When chemical fumes are present, the piping should be coated with some good chemical-resistive paint which should be in itself chemically inert and at the same time form a good bond with the exterior of the pipe. Extra care should be used in applying such paint; it should not be applied on a damp day, nor upon damp or cold surfaces; the piping should be thoroughly cleaned of all scale and dirt (the use of a stiff wire bristle brush is good for this), grease and oil; the paint should be kept thoroughly stirred and well applied, and after drying thoroughly a second coat should be applied. Two coats are usually better than more.

In some extremely exposed cases the piping has been protected by painting it with graphite paint and wrapping it with rubberized tape (such as the trimmings from rubber and canvas belts), after which the whole is given another coating of graphite paint. Cases have been known of piping protected in this way showing absolutely no sign of corrosion after six years of extremely severe exposure.

The use of galvanized piping is not very satisfactory; the cutting of the threads on the pipe removes the protective coating near the fittings where the pipe is of course the weakest, and further, the zinc forming the protective coating furnishes little protection against a great many corrosive vapors found in commercial practice.

Protection of Sprinklers.—The manufacturers of standardized sprinklers can furnish heads specially protected against corrosion, and these should be used wherever sprinklers are exposed to corrosion. At the present time two types of sprinklers are available, one being a sprinkler with a glass cover, hermetically sealed, and the other being a head coated with a corrosion-resisting compound. Care should be taken in screwing the sprinkler into the fitting not to injure this protection, otherwise its effectiveness is destroyed.

72. **Alterations.**—It is not permitted to change, plug up or remove the fittings pertaining to dry-pipe valve, pressure tanks, pumps, gauges, etc. If such fittings leak or become deranged, they are to be put in order.

73. **Extra Sprinklers.**—There should be maintained on the premises a supply of extra sprinklers (never less than six), to promptly replace any fused or in any way injured.

Sprinklers should be of the various degrees that may be used in the risk.

74. **Use of High Degree or Hard Sprinklers.**—High degree sprinklers should be used only when absolutely necessary and Inspection Department having jurisdiction should be consulted in each instance. When used, the following table should be referred to:

For ceiling temperature exceeding 100 degrees but not 150 degrees, install 212 degree heads.

For ceiling temperatures exceeding 150 degrees but not 225 degrees, install 286 degree heads.

For ceiling temperatures in excess of 225 degrees, install 360 degree heads.

Ordinary degree sprinklers should be substituted for high degree sprinklers where the latter are made unnecessary by change in occupancy.

75. **Hand Hose Connections.**—Hand hose, to be used for fire purposes only, may be attached to sprinkler pipes within a room under the following restrictions:

Pipe nipple and hose valve should be 1 inch.

Hose to be 1½ inches or 1¼ inches.

Nozzle should not be larger than ½ inch.

Hose should not be connected to any sprinkler pipe smaller than 2½ inches and never attached to a dry-pipe system.

76. **Concealed Pipe Systems.**—Concealed piping is prohibited except when the Inspection Department having jurisdiction gives consent. When installation is permitted, it should be in accordance with the following:

(a) Pipe should be of standard weight wrought iron or steel, painted with two coats of good protective paint, one before and one after installation.

(b) Should be placed in properly constructed ducts or thoroughly encased in Portland cement or equivalent. In no case shall the pipe system be installed so as to form a part of the floor arch reinforcement.

(c) When installed in the concealed space between the floor arch and ceiling, pipe should be supported by standard hangers, and all pipe, fittings and hangers should be given two coats of good protective paint.

77. **Tests After Installation.**—All systems should be tested at not less than 150 pounds pressure for 2 hours, and at 50 pounds in excess of the normal pressure when the normal pressure is in excess of 100 pounds. Emergency tests of dry-pipe systems, under at least 60 pounds air pressure, should be made at seasons of the year which will not permit testing out under water pressure.

Brine or other corrosive chemicals should not be used for testing systems.

To prevent the possibility of serious water damage in case of a break, pressure should be maintained by a small pump, the main controlling gate being meanwhile kept shut.

In the case of dry systems with differential type of dry-pipe valve, the valve should be held off its seat during the test to prevent injuring the valve.

In dry systems an air pressure of 40 pounds should be pumped up, allowed to stand 24 hours, and all leaks stopped which allow a loss of pressure of over 1½ pounds for the 24 hours.

A working test of dry-pipe valve should be made, if possible, before acceptance.

All tests should be made by contractor in presence of inspector of Inspection Department having jurisdiction.

78. **Relief Valves or Air Chambers.**—Where connections are made from public mains, subject to severe water hammer (especially where pressure is in excess of 100 pounds), it is advisable to provide a relief valve, properly connected to a drain; or an air chamber in the connection. If an air chamber is used, it should be located close to where the pipe comes through wall, and back of all other valves, and at right angle to other valves, so as to take the full force of water hammer. Air chamber shall have a capacity of not less than 4 cubic feet, shall be controlled by a standard O. S. & Y. gate valve, and shall be provided with a drain at the bottom. If an air vent is deemed desirable by the inspection department, it shall consist only of a plugged outlet.

79. **Preliminary Inspection of Sprinkler Equipments.**—Before asking final approval of an automatic sprinkler equipment by the Inspection Department having jurisdiction, the installing company should furnish a written statement, countersigned by the assured, to the effect that the work has been completed in accordance with the approved specifications and plans. The object is to secure a reasonable amount of supervision of the equipment by the assured as the work progresses, a larger knowledge on their part of its functions and proper maintenance, and also to prevent needless waste of time of the Inspection Department. Inspection Department having jurisdiction should furnish the necessary blanks for the above purpose.

Section L—Open Sprinklers

(*For Protection Against Exposure*)

Window Sprinklers

80. **Discharge Orifice.**—Where there is but one horizontal line of window sprinklers, each head should have a smooth bore tapering outlet with an unobstructed orifice ⅜ inch in diameter. Where the conditions call for more than one line the following size orifices should be used:

	2 lines.	3 lines.	4 lines.	5 lines.	6 lines.
Top line.	⅜-in.	⅜-in.	⅜-in.	⅜-in.	⅜-in.
Next low.	5/16-in.	5/16-in.	⅜-in.	⅜-in.	⅜-in.
Next low.		¼-in.	5/16-in.	5/16-in.	5/16-in.
Next low.			¼-in.	5/16-in.	5/16-in.
Next low.				¼-in.	¼-in.
Next low.					¼-in.

Where there are over six horizontal lines of windows it may be preferable to omit sprinklers on the first story or possibly even on the second story, but if over six lines are used the system should be divided horizontally with independent risers, and in some cases this may be desirable even where six lines or less are used. Thus where eight lines would be required, the four upper lines should be on one riser according to the above table and the four lower lines similarly arranged on another riser. Where over six lines are used, size of orifice should be left to the Inspection Department having jurisdiction.

Each open sprinkler head should be clearly marked on the outside as to whether it is ⅜-inch, 5/16-inch or ¼-inch orifice.

Where windows are 3 feet or less in width a size smaller orifice than required by this rule may be used, except that in no case should a size smaller than ¼ inch be used.

81. **Pipe Sizes.**—No branch line should have over six sprinklers where central riser system is used. Where gridiron system (i. e., a riser at each side with sprinklers located on the connected pipes) is used, the lines between side risers should not have over twelve heads. Branch line pipe sizes should be as follows, this applying with either central riser or gridiron system. With the gridiron system the end head is considered as being the one directly in the center (or on either side of center if the number on line be even).

(a) For ⅜-inch orifice: one head on a ¾-inch pipe; two heads on a 1-inch pipe; four heads on a 1¼-inch pipe; six heads on a 1½-inch pipe.

(b) For 5/16-inch orifice: one head on a ¾-inch pipe; three heads on a 1-inch pipe; six heads on a 1¼-inch pipe.

(c) For ¼-inch orifice: one head on a ¾-inch pipe; five heads on a 1-inch pipe; six heads on a 1¼-inch pipe.

Where heads are over twelve feet apart special pipe sizes in excess of the requirements given below should be used.

82. **Risers and Feed Mains.**—Central feed risers.

1½	inch.	Not over 6	heads.
2	inch.	Not over 10	heads.
2½	inch.	Not over 20	heads.
3	inch.	Not over 36	heads.
3½	inch.	Not over 55	heads.
4	inch.	Not over 72	heads.

For gridiron side feed risers, use the same sizes counting to the center of each line. If number on line is odd the center head may be neglected in figuring size of side risers, except that pipe feeding both risers must take into account all sprinklers which it feeds. Where feed main (including risers to the first branch line) is over twenty-five feet in length, feed main should be at least a size larger than the tables require. Where there is more than one riser, size of feed mains should be determined by the Inspection Department having jurisdiction but should never be less than the full equivalent of the two largest risers.

At all dead ends a tee instead of an elbow should be used and a piece of pipe 6 inches long with brass plug in end should be screwed into tee to form a pocket for collecting dirt.

Where sprinklers run on two adjoining sides of a building with separate controlling valve for each side, the end lines should be connected together with check valves so located that one head around the corner will operate when valve is opened.

Strainers of a standard type should be installed at base of risers, or in connection to same. Strainers should be so located as to be easily accessible for cleaning.

83. **Pipe.**—Galvanized wrought iron (or other standard) pipe should be used for the equipment as far back as the cast iron pipe. All galvanizing of pipe should be done in a careful and thoroughly workmanlike manner.

Pipe should be securely supported in a manner fully equal to that required for automatic sprinklers.

All pipe should be carefully inspected before being installed.

84. **Valves.**—Where central feed risers are used each should have a controlling valve. Where side feed risers are used they are to be connected together at bottom and one valve so located as to control the two risers. Valves should be of standard type as required for automatic sprinkler systems. Distinct marking of each valve by letters not less than one-half inch high is required. Riser valves should be so located as to be easily accessible, preferably in first story.

85. **Drainage.**—All pipes and fittings should be carefully arranged and pitched so as to thoroughly drain the entire system as far back as the inside riser controlling valve. Drip pipes should be not less than 1 inch in size.

86. **Location and Number of Sprinklers.**—For windows not exceeding five feet wide one sprinkler should be placed at center near top, so located that the water discharge therefrom will thoroughly wet the upper part of the window, and by running down over the sash and glass wet to the greatest extent the entire window. Where windows are over five feet wide, or where mullions interfere, two or more heads should be used; this, together with size of orifice, should be determined by the Inspection Department having jurisdiction, it being understood that two ¼-inch heads are approximately the equivalent of one ⅜-inch.

For windows five to six feet wide one sprinkler may be used by special consent of the Inspection Department having jurisdiction.

87. **Water Supply and Control.**—Supply to open sprinklers should be town waterworks, standpipe, pump or steamer connection, but never pressure or gravity tank used to supply automatic sprinklers, except that such gravity tank may be used in case additional capacity is provided.

Where water supplies feed other fire protective appliances, such as automatic sprinklers or hydrants, system should be so arranged that there is no danger of impairing the efficiency of such other devices, and water supply should be of sufficient capacity to adequately feed such appliances even with the open sprinklers in operation. Supply should be of sufficient capacity to feed all sprinklers designed to be operated at one time and maintain not less than 10 pounds pressure at top of riser for a length of time depending on conditions, but not less than 60 minutes. Where steamer connections are used they shall be located so as to be safe from the exposing fire, as in the rear of building if exposure is on the front. Where other water supplies are used and it is desirable or necessary to save such supplies for other service in case the open sprinklers are ineffectual, locate a controlling valve or valves outside the building itself and accessible as regards the exposure fire. Such valves may be located in properly cut off valve rooms or pits by special consent of the Inspection Department having jurisdiction. Underground controlling valves should be in approved pits with manhole or be fitted with standard post indicators.

88. **Sprinklers.**—Only such types of window, cornice, side wall or ridge pole sprinklers should be installed as have been standardized for such use.

89. **Gauge Connections.**—Plugged outlets for gauge connections should be provided at the top of each riser and just below the con-

trolling valve of each riser. Such outlets should be piped into the building for the purpose of conveniently attaching a test pressure gauge.

Cornice, Side Wall or Ridge Pole Sprinklers

(*For use in protecting frame buildings, mansard roofs, etc.*)

90. **Location, Size of Orifice and Number.**—Where one line only is required, as for the mansard roofs of a brick building or for low frame buildings, the heads should not be less than ⅜-inch orifice and not over eight feet apart on the line. Pipe sizes and arrangement should be the same as for window sprinklers. Where the number of sprinklers and water supplies admit, it may be desirable to use a 7/16- or ½-inch orifice with pipe sizes not less than the following: 1 on 1-inch; 3 on 1¼-inches, 5 on 1½-inches, 8 on 2-inches. Where frame buildings are over two stories high it will be generally necessary to have two or more horizontal lines, preferably one line at each of the upper stories beginning at the eaves line, the heads located over each vertical row of windows where windows are not over eight feet center to center. Size of orifice and pipe sizes should be same as for window sprinklers except by special consent of the Inspection Department having jurisdiction. The value of open sprinklers for frame buildings is much enhanced by the use of wood shutters at all window openings.

Section M—Underground Pipes and Fittings

91. **Weights.**—Should not be less than those specified in the following table, where the normal pressures do not exceed 125 pounds. Where the normal pressures are in excess of 125 pounds heavier piping should be used:

Pipe	Weight per ft. Including Sockets
4 inches	23.0 pounds
6 inches	35.8 pounds
8 inches	52.1 pounds
10 inches	70.8 pounds
12 inches	91.7 pounds
14 inches	116.7 pounds
16 inches	143.8 pounds

Pipe should be made in accordance with the essential features of the "Standard Specifications for Cast-Iron Pipe and Special Castings," adopted by the American Water Works Association, May 12, 1908. The inspector referred to in the Specifications should preferably be a representative of an independent inspection bureau making a business of examinations and tests of pipe of this character. In cases where the amount of pipe to be installed does not warrant the expense involved in a special examination, a certificate from the manufacturer, stating that the pipe has been made and tested as required, may be accepted by Inspection Department having jurisdiction, to whom the matter should be referred in advance of closing the contract.

92. **Hydrant Main.**—No 4-inch pipe shall be used.

93. **For Pipes Extending to a Dead End:**—

(a) Allow 200 feet 6-inch pipe with one 3-way hydrant.

(b) Allow 500 feet 6-inch pipe with one 2-way hydrant. This might be extended in special cases.

(c) Allow 1,000 feet 8-inch pipe with one 3-way hydrant.

(d) Allow 500 feet 8-inch pipe with one 4-way hydrant or its equivalent in hose streams.

(e) Allow 300 feet 8-inch pipe to first hydrant, where there is a hydrant equivalent of 6 streams.

(f) **Limit for Four Streams.**—Whereas the above limitations for 8-inch pipe are low, it is deemed undesirable to have over 4 streams on a dead end, and the loop system would ordinarily be employed where it is intended to concentrate over 4 streams at one point.

(g) **Limit for Three Streams.**—Never allow more than three (3) streams on 6-inch branch pipe.

94. **For Loop Systems:**—

(a) **For Two 3-Way Hydrants.**—With two 3-way hydrants, say 250 feet apart, allow 250 feet 6-inch pipe from each hydrant toward source (preferably use 8-inch pipe with 3-way hydrant systems).

(b) **For Two 2-Way Hydrants.**—With two 2-way hydrants, say 250 feet apart, allow 500 feet pipe from each hydrant toward source.

(c) **For Three 2-Way Hydrants.**—With three 2-way hydrants, 250 feet apart, allow 250 feet 6-inch pipe from end hydrants toward source.

(d) **For Four 2-Way Hydrants.**—To feed four 2-way hydrants, or their equivalent, use 8-inch main feed pipes and allow 500 feet of 8-inch pipe each way from end hydrant to water supply, rest of pipe 6-inch, if desired.

(e) **For Five 2-Way Hydrants.**—To feed five 2-way hydrants or their equivalent, use 8-inch main feed and allow 250 feet from end hydrants to water supply.

(f) **For Over Four Streams.**—Where water supplies are such that over four streams can be obtained, loop pipes should never be less than 8-inch.

(g) **For Over Six Streams.**—In laying out a loop system where it is intended to concentrate 4 to 6 streams at any one point, an 8-inch loop should be amply sufficient even if it is as much as 1,000 feet from supply to point of concentration.

(h) **For Large Number of Streams.**—Under conditions where a large number of streams can be concentrated at one point, it would sometimes be desirable to use 10-inch or 12-inch pipe.

95. **Rules for Laying Cast-iron Mains.—Depth of Earth Cover.**—The depth of covering should be determined by the Inspection Department having jurisdiction, but will vary from 2½ feet in the Southern States to 10 feet in the northern part of Canada. Depth of covering should be measured from top of pipe to ground level. In a loose, gravelly soil, or in rock, the depth should be greater than in compact, clayey soil. A safe rule to follow is to bury the top of the pipe not less than one foot below the lowest frost line for the locality. As there is normally no circulation of water in private fire mains, they require a greater covering than the public mains.

Placing pipes over raceways or near embankment walls should be avoided as far as possible, and special attention given to protection against frost where it is necessary to so locate them.

Where mains are laid in raceways or shallow streams, care should be taken that there will be a sufficient depth of running water between the pipe and the frost line during all seasons of frost, and a safer method is to bury the main under the bed of the waterway not less than one foot. Care should also be taken to keep the mains back from the banks a sufficient distance to avoid any danger of freezing through the side of the bank above the water line, and with low banks mains should be buried below the frost line where entering the water.

96. **Care in Laying.**—Pipes should be clean inside when put in trenches, and open ends plugged when work is stopped, to prevent stones rolling inside.

Pipes should bear throughout their length, and not be supported by the bell ends only.

Specials.—Specials should be used for making offsets and bends, and reducers for changing size of pipes, as thick lead joints or joints with lead mostly on one side are liable to leak.

Back Filling.—Back filling should be well tamped under and around pipes to prevent settlement or lateral movement, and should contain no ashes, cinders or other corrosive materials.

Rocks should not be rolled into trenches and allowed to drop on pipes.

All plugs at blanked openings and all bends in soft ground should either be strapped or secured by masses of concrete against the ends or sides of trenches to avoid any possibility of joints blowing apart.

In trenches cut through rock, back filling should preferably be entirely of earth, but earth shall be used under and around pipe, and for at least 2 feet above same. If soil is of quicksand it may be necessary to support piping on piers. Under railroad tracks, pipe should be provided with special supports and reinforcement at joints. Underground, through buildings, flanged cast-iron pipe with metallic gaskets or other standard pipe should be used.

Mains should not be laid under piles of coal or other material liable to make the ground settle and cause leaks.

Steep Inclines.—Down steep hills mains should be properly anchored. A general rule is to anchor the pipe at the bottom of the hill, at any turns, and otherwise on straight runs about every forty-eight feet. The anchoring should be done either to natural rock or by means of brick or concrete piers. The piers should be built around the pipe, or an iron rod not less than ¾ inch in diameter placed around the pipe and the ends anchored in the piers. Bell ends should be uphill.

Blow-off.—Where feasible, blow-off should be provided at low point of underground main, and it is also advisable where an underground main crosses water.

Clamps.—Clamp rods where used for strapping pipe should preferably run from the bell to the next bell or fitting, but may be run to clamps on pipe, provided clamps are not less than 1½ inches wide and not less than ⅜ inch thick. For 8-inch pipe and smaller, clamp rods should not be less than ⅝ inch in diameter; for larger pipe not less than ¾ inch. Clamps, straps or rods should be protected against corrosion by painting with tar, asphaltum or by other suitable means.

Leading Joints.—Joints should be carefully leaded, and packing should be in the smallest quantity necessary to stop the lead. Rings should be shrunk on ends of short length of pipe to form beads. These are very essential in order to prevent yarn and lead from passing into pipe, and also to make joint hold. Socket joints should not be located in, or close to, foundations.

97. **Locating, and Setting Hydrants.**—Hydrants should be of a standard type (see special pamphlet on Valves, Indicator Posts and Hydrants), and wherever possible placed about 50 feet from the buildings protected. Where it is impossible to place them at this distance, they may be put nearer, provided they are set in locations where the chance of injury by falling walls is small, and from which men are not likely to be driven by smoke or heat. Usually in crowded mill yards they can be placed beside low buildings, near brick stair towers, or at angles formed by substantial brick walls which are not likely to fall. Hydrant should be set on flat stone and about half a barrel of small stones placed about the bottom to insure quick drainage from the drip. They should not be placed near retaining walls where there is danger of frost through the wall.

Hydrants should be fastened to pipe by strap from lugs cast on hydrant or other means acceptable to the Inspection Department having jurisdiction.

Where soil is of such a nature that the hydrants will not drain properly under the above arrangement, the hydrant drain should be connected to a sewer or ground drain by not less than a 2-inch cast-iron pipe; or some other means acceptable to the Inspection Department having jurisdiction should be provided to keep the hydrant barrels clear of water.

For hose house and equipment, see page 661.

98. **Valves.**—Every connection from a yard main to a building should be provided with a post indicator valve of a standard type, and the name of the service controlled should be clearly stencilled on the valve.

When surroundings are such that the indicator post will interfere with the passing of teams or cars, the best practice is to use a valve of the outside screw and yoke pattern placed in a pit built in accordance with the National Board of Fire Underwriters' Regulations. (See special pamphlet on Tanks.) A wrench or crowfoot with long handle should be provided for each valve, and kept in the pit where it can be reached from the yard level. The location of the valve should be clearly marked on neighboring buildings, and the cover of the pit should be kept at all times free from dirt and snow.

Large yard systems should have sectional controlling valves, and a valve should be provided on each bank where a main crosses water.

99. **Testing.**—All piping when completed should be tested for not less than two hours at a pressure of not less than 150 pounds, and if the normal pressure exceeds 100 pounds, for not less than 50 pounds in excess of that pressure.

Where feasible, test should be made with fire pumps running, and every hydrant should be opened and closed so as to test it, and at the same time produce some water hammer on the piping, as in the case of actual fire. The system should also be thoroughly flushed out by opening the various hydrants wide, thus drawing large quantities of water and cleaning out small stones, sand and other obstructions which will plug play pipes and sprinklers if allowed to remain until the time of fire.

Branches to the inside sprinkler equipment should also be flushed out before connecting the sprinkler riser.

If fire pumps are not available, underground piping may be tested out by means of a hand pump.

In any event, the system should be tested under water pressure to detect leaks which, even if small, when running continuously, cause large waste of water, and if possible pressure should be put on the pipes before the joints are covered, in order that any leaks may be readily located. Tests should be made by contractor in presence of inspector of the Inspection Department having jurisdiction.

EDITOR'S NOTE.—See Appendix for section N, rules 100 to 103, inclusive.

FRICTION LOSS IN PIPE AND FITTINGS

Kind and Age of Pipe.—On the tables on pages 578 and 579 are given the friction loss, as calculated on the Hazen-William's hydraulic slide rule, in cast-iron pipe 15 to 20 years old and ordinary wrought-iron pipe. The discharge is approximately 80 per cent. of these figures for cast-iron pipe 30 to 40 years old and old wrought-iron pipe. For cast-iron pipe about 5 years old, smooth new wrought-iron and ordinary wood-stave pipe and cement-lined pipe, the carrying capacity is about 20 per cent. greater than the table for the same friction loss. Ordinary straight brass, lead, glass and tin pipe has a capacity about 30 per cent. greater than the figures given.

Bends and Other Fittings.—The loss of head at bends and at enlargement and contraction of pipe sizes is usually figured as a function of the velocity head. For any flow, the velocity head can be obtained by the formula—

$$\text{v. h.} = \frac{q^2}{888d^4}$$

Where v. h. equals the velocity head in pounds, q equals the quantity in gallons per minute, and d equals the diameter of the pipe in inches.

From tests made by Inspection Department of the Associated Factory Mutual Fire Insurance Companies:

Long-turn ells give a loss equal to about 0.3 velocity head or the same friction loss as 4 feet of straight pipe of the same size, while short-turn ells have a loss equivalent to 1.0 velocity head or 9 feet of pipe.

Long-turn tees have a loss equal to 1.0 velocity head or are the equivalent of 9 feet of straight pipe, while short-turn tees have a loss of 1.5 velocity head or are the equivalent of 17 feet.

Six-inch straight way check valve (Pratt & Cady pattern) is the equivalent of 50 feet of 6-inch pipe.

Four-inch Pratt & Cady check valve is the equivalent of 25 feet of 4-inch pipe.

Six-inch Grinnell dry pipe valve (old style differential) is the equivalent of 80 feet of 6-inch pipe.

Six-inch English alarm check is the equivalent of 100 feet of 6-inch pipe.

Four-inch Grinnell dry pipe valve (old style differential) and 4-inch English alarm check are each the equivalent of 47 feet of 4-inch pipe.

Tests made by the National Board of Fire Underwriters indicate a loss as follows:

Pressure regulators have a loss of about 10. velocity head or about that due to 150 feet of pipe.

Globe valves show about the same loss as regulators.

Angle valves have a loss of about 2 velocity heads, or the equivalent of 20 feet of pipe.

APPROXIMATE COST OF LAYING CAST IRON PIPE

Based on $30.00 per ton for pipe, macadam at $0.60 per sq. yd. and block, brick, wood, etc., at $2.00 per sq. yd. Paving figured 2 feet wider than trench.

These figures will not pay for large gates, but some allowance is made for specials.

Hydrants set, including connection, $40.00.

Diameter of pipe, inches	Price per foot, laid	Repaving at $0.60 per square yard	Repaving at $2.00 per square yard	Cost per foot, macadam pavement	Cost per foot, block, brick or asphalt pavement
6	$0.80	$0.26	$0.88	$1.06	$1.68
8	1.10	0.26	0.88	1.36	1.98
10	1.40	0.26	0.88	1.66	2.28
12	1.75	0.26	0.88	2.01	2.63
16	2.50	0.29	0.96	2.79	3.46
20	3.50	0.31	1.02	3.81	4.52
24	4.50	0.33	1.10	4.83	5.60
30	6.00	0.36	1.22	6.36	7.22
36	7.50	0.40	1.34	7.90	8.84
42	9.50	0.43	1.44	9.93	10.94
48	12.00	0.47	1.56	12.47	13.56

LOSS OF HEAD THROUGH TAPS AND SERVICES—Assumed Length of Service= 30 Ft.

Flow in Gallons per Minute	Diameter of Service with Size of Taps as Indicated Below																	
	2″ Service							1½″ Service					1″ Service			¾″ Service		⅝″ S.
	2″ Without Strainer	2″ With Strainer	1½″ Without Strainer	1½″ With Strainer	1″	¾″	⅝″	1½″ Without Strainer	1½″ With Strainer	1″	¾″	⅝″	1″	¾″	⅝″	¾″	⅝″	⅝″
5																2	2	3
10																5	6	10
15													3	4	5	11	12	23
20							5					5	5	6	9	18	21	38
25						3	7				4	8	8	10	14	28	32	54
30						5	11			2	5	12	11	14	20	39	46	
40					3	8	19	2	3	4	10	21	18	24	35	69	80	
50					4	13	30	4	5	7	15	32	28	37	54			
60				3	6	18	43	5	7	9	22	47	39	51	76			
70				4	8	25	63	7	9	13	30	68	52	69				
80				5	10	33		9	11	17	40		68					
90		3	3	6	13	42		12	14	21	50							
100	3	4	4	7	16	51		14	17	26								
125	5	6	7	12	25	77		22	27	40								
150	8	9	10	17	36			30	38	57								
175	10	12	13	23	49			41	51	77								
200	13	16	16	29	62			52	65									
225	17	20	20	37				65										
250	20	24	25	45														
275	24	29	30	55														
300	29	35	36	64														

LOSS THROUGH 10 FEET OF LEAD PIPE

Gals. per Min.	5	10	15	20	25	30	40	50	60	70	80	90	100	125	150	175	200	225	250	275	300
⅝″	1	3	6	10	14																
¾″		2	3	5	8	11	18														
1″				1	2	3	5	7	10	13	17										
1½″									1	2	2	3	3	5	7	10	12	15			
2″															1	2	2	3	3	4	5

NOTE.—The figures given in the upper table are the pressures in pounds per square inch required in the street main to discharge the given flow freely through the various combinations of services and taps as indicated and are equivalent to the differences of pressure between the street main and the end of the service when discharging the given flows directly into the house plumbing under pressure. The length of all services has been assumed as 30 feet. The losses in both taps and services were taken from curves obtained from tests made by the Department of Water Supply, Gas and Electricity of New York. The figures include the velocity head in the service pipe. The lower table gives the losses in pounds per square inch for 10 feet of lead pipe and can be used in conjunction with the upper table when the length of the service is greater or less than 30 feet.

FRICTION LOSS IN ORDINARY WROUGHT IRON AND CAST IRON PIPE

GALLONS		LOSS IN POUNDS PER 100 FEET OF PIPE									
Per minute	Per day	½"	¾"	1"	1¼"	1½"	2"	2½"	3"	4"	5"
5	7,200	18	4.5	1.4	0.4	0.2	0.1				
10	14,400	64	16	5.0	1.3	0.6	0.2	0.1			
15	21,600	135	34	11	2.7	1.3	0.5	0.2			
20	28,800		59.	18.	4.7	2.2	0.8	0.3	0.1		
25	36,000		89.	27.	7.1	3.4	1.2	0.4			
30	43,200		125.	39.	10.	4.7	1.7	0.6	0.2		
35	50,400		165.	51.	13.	6.3	2.2	0.7	0.3		
40	57,600			66.	17.	8.0	2.9	0.9	0.4	0.1	
45	64,800			82.	21.	10.	3.6	1.2	0.5		
50	72,000			99.	26.	12.	4.3	1.4	0.6		
60	86,400			140.	38.	17.	6.1	2.0	0.8	0.2	
70	100,800				49.	23.	8.0	2.7	1.1	0.3	
80	115,200				63.	29.	10.3	3.4	1.5		0.1
90	129,600				78.	36.	13.	4.3	1.8	0.4	
100	144,000				96.	44.	15.	5.1	2.2	0.5	0.2
125	180,000				144.	66.	24.	7.8	3.3	0.8	0.3
150	216,000				200.	93.	33.	11.	4.6	1.1	0.4
175	252,000					125.	44.	15.	6.1	1.5	0.5
200	288,000					158.	56.	19.	7.8	1.9	0.6
250	360,000						84.	28.	12.	2.9	1.0
300	432,000						114.	40.	16.	4.0	1.3
350	504,000						151.	53.	22.	5.4	1.8
400	576,000							68.	28.	6.9	2.3
450	648,000							84.	35.	8.6	2.9
500	720,000							102.	42.	10.	3.5
1,000	1,440,000								154.	37.	13.
2,000	2,160,000									135.	44.

FRICTION LOSS IN ORDINARY WROUGHT IRON AND CAST IRON PIPE—Continued

GALLONS		LOSS IN POUNDS PER 1,000 FEET OF PIPE								
Per minute	Per day	6"	8"	10"	12"	14"	16"	18"	20"	24"
25	36,000	0.1								
50	72,000	0.2	0.1							
100	144,000	0.8	0.2	0.1						
200	288,000	2.7	0.7	0.2	0.1					
300	432,000	5.8	1.4	0.4	0.2	0.1				
400	576,000	9.9	2.4	0.7	.03		0.1			
500	720,000	15.	3.6	1.2	0.5	0.2	0.2	0.1		
1,000	1,440,000	52.	13.	4.3	1.8	0.8	0.5	0.2	0.1	
1,500	2,160,000	111.	27.	9.1	3.8	1.7	0.9	0.5	0.3	0.1
2,000	2,880,000	190.	47.	16.	6.5	2.9	1.6	0.9	0.5	0.2
2,500	3,600,000	287.	71.	24.	10.	4.4	2.4	1.4	0.8	0.3
3,000	4,320,000		99.	33.	14.	6.6	3.4	1.9	1.1	0.5
3,500	5,040,000		132.	44.	18.	8.2	4.5	2.5	1.5	0.6
4,000	5,760,000		166.	56.	23.	11.	5.8	3.3	1.9	0.8
4,500	6,480,000		208.	70.	29.	14.	7.2	4.1	2.4	1.0
5,000	7,200,000		252.	86.	35.	17.	8.8	4.9	2.9	1.2

Table showing Equivalant values of Pipe Capacity

Figured on H and W Hyd. Slide Rule

Diam. Inches	S=1.0 C=100		Diameter of Pipe in Inches																Diam. Inches
	Quantity	Vel.	4	6	8	10	12	14	16	20	24	30	36	42	48	54	60	66	
66	59,400,000	3.87	1592	550	257	143	88.6	59.1	41.5	23.1	14.3	7.95	4.94	3.28	2.31	1.70	1.29	1.	66
60	46,200,000	3.64	1239	428	200	111.2	69.0	45.9	32.3	18.0	11.12	6.19	3.84	2.55	1.80	1.32	1		60
54	35,000,000	3.41	938	324	151.5	84.4	52.3	34.6	24.5	13.6	8.44	4.69	2.91	1.94	1.36	1			54
48	25,700,000	3.17	689	238	111.2	61.9	38.4	25.6	18.0	10.0	6.19	3.44	2.14	1.42	1				48
42	18,100,000	2.91	486	167.6	78.4	43.6	27.0	18.0	12.7	7.04	4.36	2.42	1.50	1					42
36	12,030,000	2.64	323	111.2	52.2	29.0	18.0	12.0	8.42	4.68	2.90	1.61	1.						36
30	7,470,000	2.35	200	69.2	32.4	18.0	11.13	7.43	5.22	2.91	1.80	1							30
24	4,150,000	2.04	111.2	38.4	18.0	10.0	6.19	4.13	2.90	1.61	1.								24
20	2,570,000	1.82	68.9	23.8	11.12	6.19	3.84	2.56	1.80	1.									20
16	1,430,000	1.58	38.4	13.3	6.19	3.45	2.14	1.42	1.										16
14	1,005,000	1.45	26.9	9.31	4.35	2.42	1.50	1											14
12	670,000	1.32	18.0	6.21	2.90	1.61	1												12
10	415,000	1.18	11.12	3.84	1.80	1													10
8	231,000	1.02	6.19	2.14	1														8
6	105,000	.85	2.90	1															6
4	37,000	.66	1.																4

NEW ENGLAND WATER WORKS ASSOCIATION. STANDARD CAST IRON WATER PIPE

MADE IN LENGTHS TO LAY 12 FEET NET

Nominal Diameter Pipe	Class A		Class B		Class C		Class D		Class E		Class F		Class G		Class H		Class I		Class K	
	Thickness of Shell Inch	Weight per Length Lbs.	Thickness of Shell Inch	Weight per Length Lbs.	Thickness of Shell Inch	Weight per Length Lbs.	Thickness of Shell Inch	Weight per Length Lbs.	Thickness of Shell Inch	Weight per Length Lbs.	Thickness of Shell Inch	Weight per Length Lbs.	Thickness of Shell Inch	Weight per Length Lbs.	Thickness of Shell Inch	Weight per Length Lbs.	Thickness of Shell Inch	Weight per Length Lbs.	Thickness of Shell Inch	Weight per Length Lbs.
4	.34	200			.36	215			.39	230			.42	250			.45	265	.48	289
6	.38	330			.42	350			.46	380			.50	420			.50	454		
8	.42	475			.48	530			.53	575			.58	640			.63	690		
10	.47	650	.50	680	.53	720	.56	760	.60	810	.63	850	.67	890	.70	935				
12	.49	810	.53	855	.57	910	.61	970	.65	1040	.69	1100	.73	1160	.77	1220				
14	.53	1010	.57	1080	.61	1150	.66	1220	.70	1310	.75	1390	.79	1460	.83	1530				
16	.55	1215	.60	1300	.65	1390	.70	1490	.75	1610	.80	1710	.85	1810	.90	1900				
18	.57	1400	.63	1520	.69	1660	.75	1780	.80	1910	.86	2040								
20	.60	1610	.66	1760	.72	1920	.79	2090	.85	2260	.92	2420								
24	.64	2050	.72	2290	.80	2550	.88	2780	.95	3000	1.03	3240								
30	.71	2860	.81	3230	.91	3600	1.01	3150	1.10	4340	1.20	4700								
36	.79	3800	.90	4270	1.02	4840	1.13	5310	1.25	5900	1.37	6400								

AMERICAN WATER WORKS ASSOCIATION. STANDARD CAST IRON WATER PIPE

MADE IN LENGTHS TO LAY 12 FEET NET

Nominal Inside Diameter, Inches	CLASS A 100-Feet Head 43 Pounds Pressure			CLASS B 200-Feet Head 86 Pounds Pressure			CLASS C 300-Feet Head 130 Pounds Pressure			CLASS D 400-Feet Head 173 Pounds Pressure		
	Thickness Inches	Weight per—		Thickness Inches	Weight per—		Thickness Inches	Weight per—		Thickness Inches	Weight per—	
		Foot	Length		Foot	Length		Foot	Length		Foot	Length
4	.42	20.0	240	.45	21.7	260	.48	23.3	280	.52	25.0	300
6	.44	30.8	370	.48	33.3	400	.51	35.8	430	.55	38.3	460
8	.46	42.9	515	.51	47.5	570	.56	52.1	625	.60	55.8	670
10	.50	57.1	685	.57	63.8	765	.62	70.8	850	.68	76.7	920
12	.54	72.5	870	.62	82.1	985	.68	91.7	1100	.75	100.0	1200
14	.57	89.6	1075	.66	102.5	1230	.74	116.7	1400	.82	129.2	1550
16	.60	108.3	1300	.70	125.0	1500	.80	143.8	1725	.89	158.3	1900
18	.64	129.2	1550	.75	150.0	1800	.87	175.0	2100	.96	191.7	2300
20	.67	150.0	1800	.80	175.0	2100	.92	208.3	2500	1.03	229.2	2750
24	.76	204.2	2450	.89	233.3	2800	1.04	279.2	3350	1.16	306.7	3680
30	.88	291.7	3500	1.03	333.3	4000	1.20	400.0	4800	1.37	450.0	5400
36	.99	391.7	4700	1.15	454.2	5450	1.36	545.8	6550	1.58	625.0	7500

AUTOMATIC SPRINKLER ILLUSTRATIONS

On the following pages will be found illustrations of more than 100 automatic sprinkler heads of different varieties. Many of these are of obsolete designs, and are not now manufactured, and for that reason are likely to puzzle the average inspector when he meets them in his rounds. These illustrations should aid in the identification of practically all sprinkler heads which are in use, whether installed recently or in the earlier years of this form of protection, and will doubtless render valuable assistance to inspectors and surveyors, and also to property owners desirous of describing the equipment of their premises.

The index presented below will enable the render to readily find the picture of any desired type of sprinkler, while the titles (referred to by number) given at the bottoms of pages, will identify by name any selected illustration.

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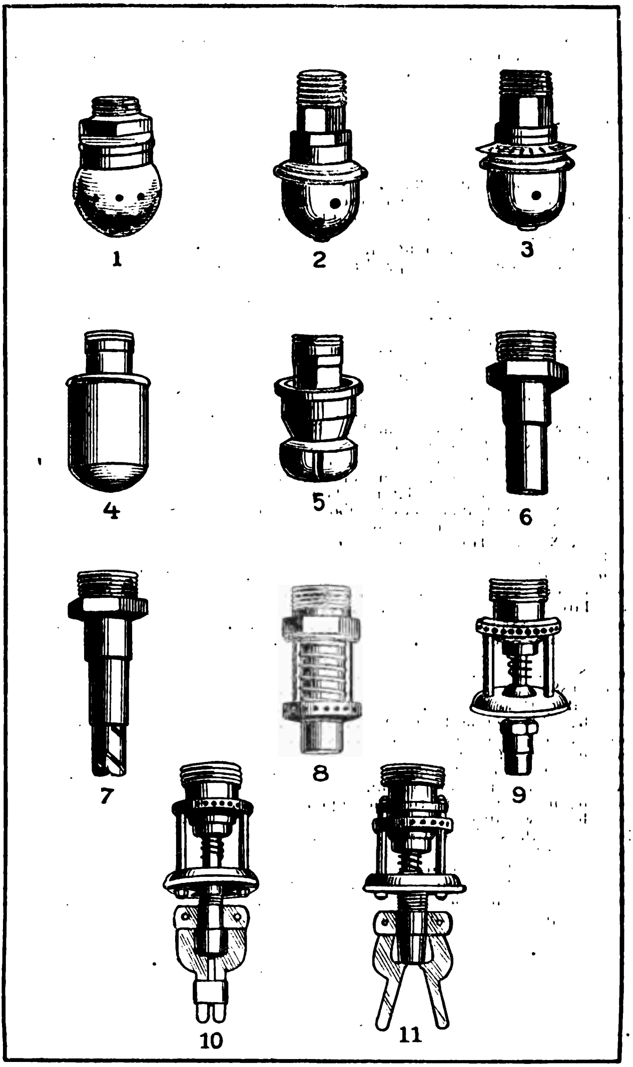
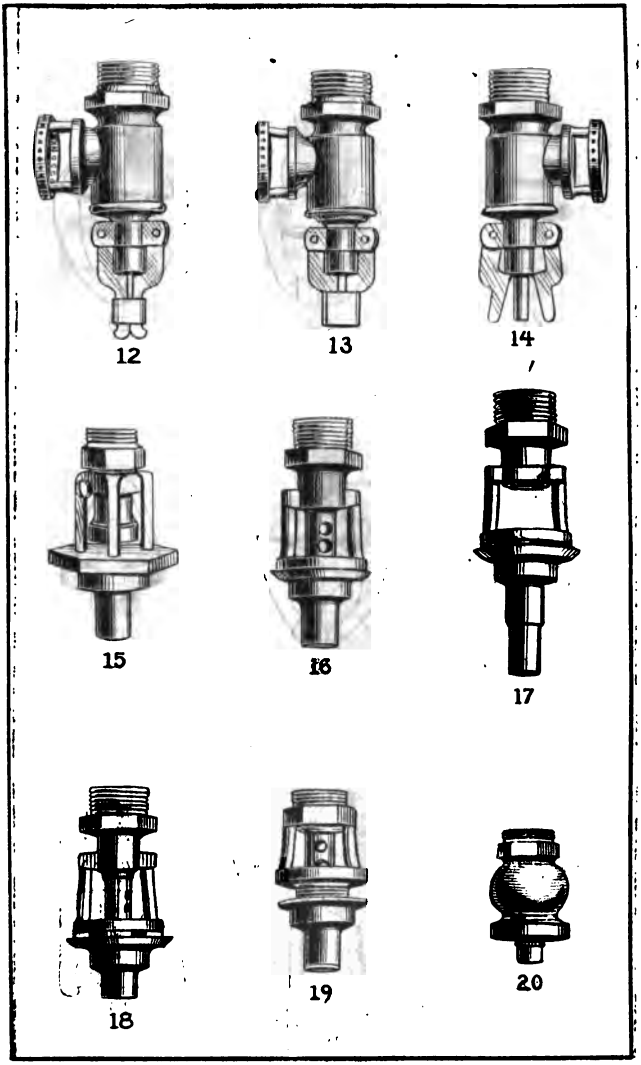
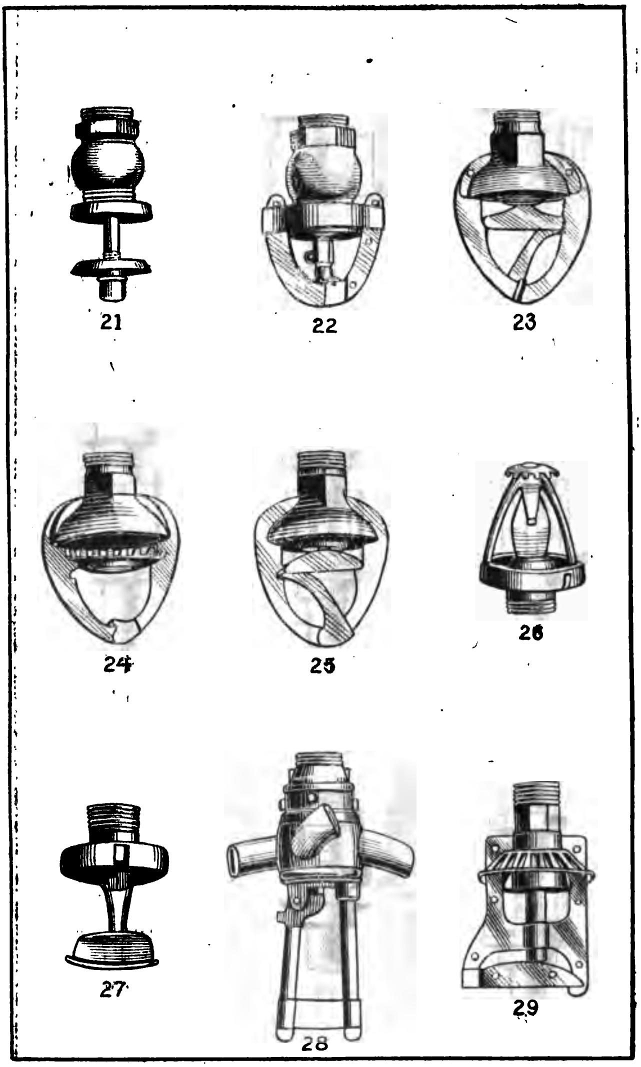


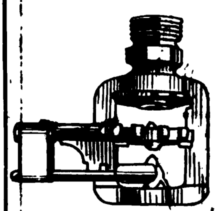
1—Burritt; perforated, 1877. 2—Burritt; water joint. 3—Burritt; water joint; deflector; 1881. 4—Parmalee; 1878. 5—Parmalee; open. 6—Bishop; old water joint; 1881. 7—Bishop; old water joint; open. 8—Bishop; later water joint. 9—New York & New Haven; thimble; 1883. 10—New York & New Haven; link. 11—New York & New Haven; link; open.



12—New York & New Haven; older; elbow; 1888. 13—New York & New Haven; later; elbow. 14—New York & New Haven; later; elbow; open. 15—Harris; 1883. 16—Gray; old; long nipple; 1886. 17—Gray; old; long nipple; open. 18—Gray; old; short nipple. 19—Gray; new; 1891. 20—Brown; No. 1; 1881.



21—Brown; No. 1; open. 22—Brown; No. 2; 1883. 23—Grinnell; old; pendant; wide seat rings; lead discs, 1882 to 1884; tin, 1884 to 1886; narrow seat rings, tin, 1886 to 1888; babbitt metal, from April, 1888. 24—Grinnell; old; pendant; open. 25—Grinnell; old; upright; 1883. 26—Grinnell; new; Oct. 2, 1890. 27—Grinnell; open; eaves. 28—Neracher; lawn; 1882. 29—Neracher, yoke link; 1883.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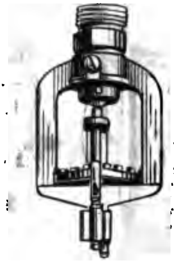
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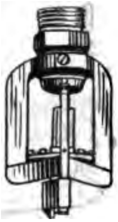
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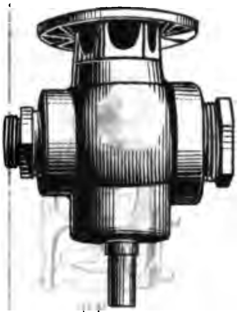
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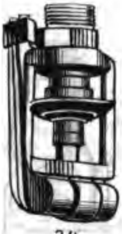
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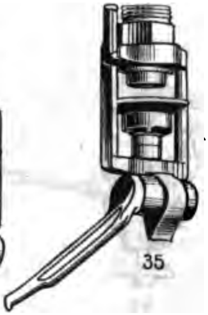
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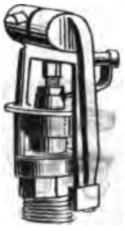
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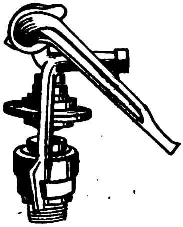
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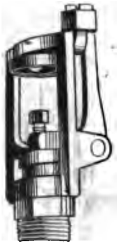
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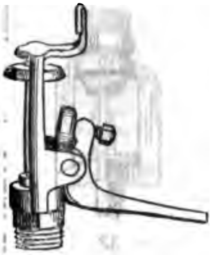
30—Neracher; side links; 1884. 31—Neracher; regular; older; 1888. 32—Neracher; regular; later. 33—Hopedale. 34—Walworth; old; pendant; 1883. 35—Walworth; old; pendant; open. 36—Walworth; old; upright. 37—Walworth; old; upright; open. 38—Walworth; new; upright; turbine.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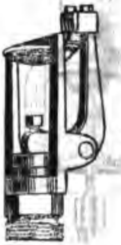
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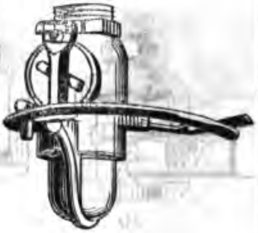
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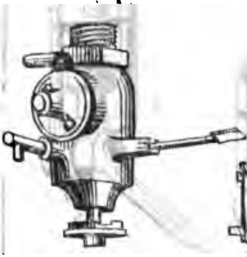
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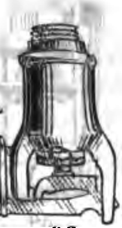
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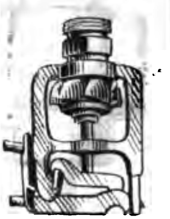
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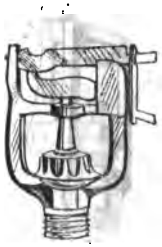
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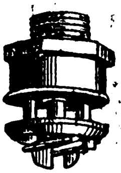
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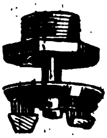
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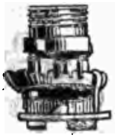
39—Walworth; new; upright; turbine; open. 40—Walworth; new; disc. 41—Kane Eclipse. 42—Kane Eclipse; open. 43—Kane; old. 44—Kane; new. 45—Kane; universal. 46—Mackey; box; 1884. 47—Mackey; disc.



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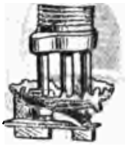

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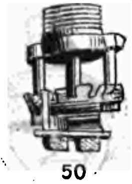

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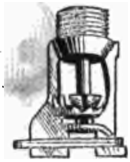

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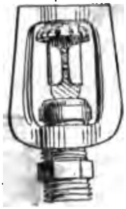

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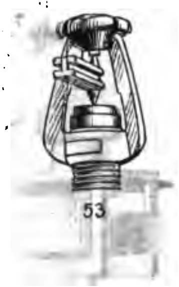

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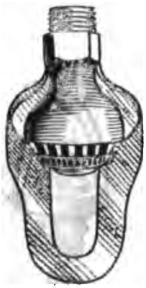

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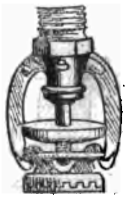

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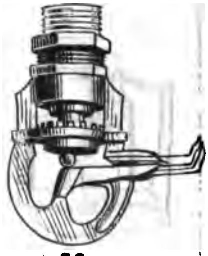
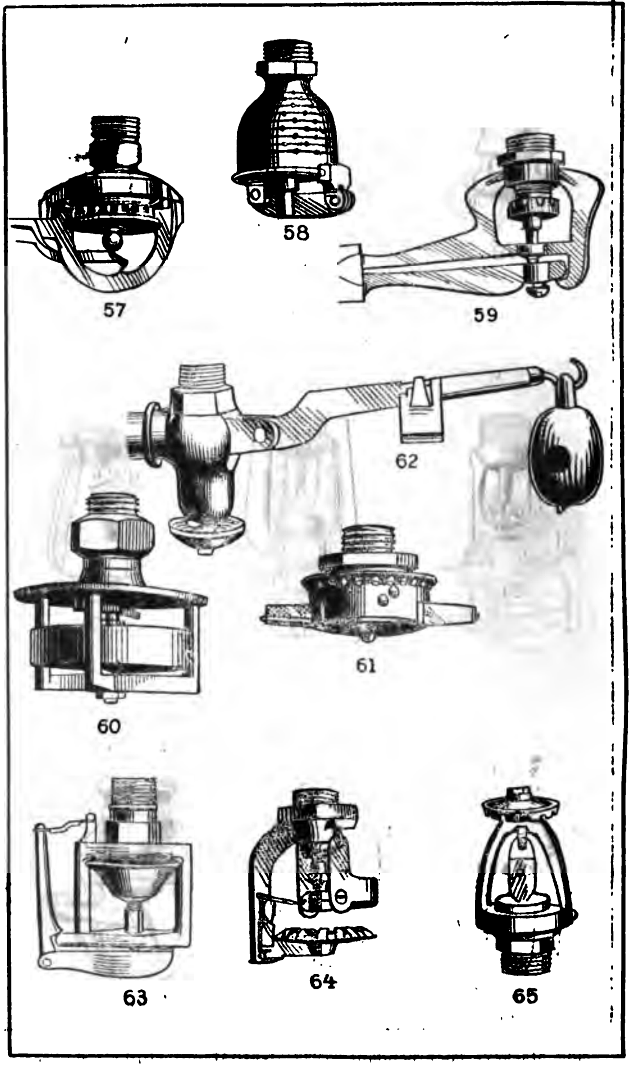
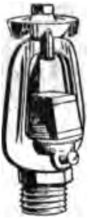


56

48—Mackey; later pendant; 1888. 49—Manufacturers; flat screw; pendant; 1892. 50—Manufacturers; round screw; pendant; 1894. 51—Manufacturers; mutual. 52—Manufacturers; yoke; upright; 1894. 53—Manufacturers; duck bill; upright. 54—Buell; old. 55—Buell; later; 1882. 56—Harkness; old; 1885.



57—Harkness; later; 1891. 58—Barnes; perforated. 59—Barnes; lever and link; 1880. 60—Draper. 61—Nagle; 1886. 62—Gleason. 63—Gunn. 64—Kersteter; older; 1887. 65—Kersteter; later.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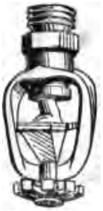
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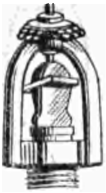
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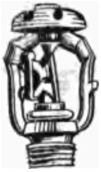
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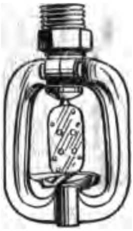
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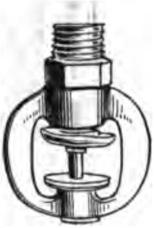
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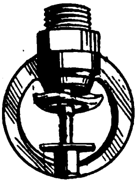
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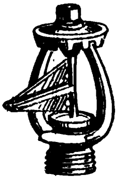
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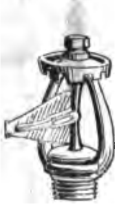
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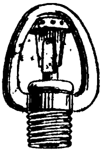
66—Pierce; older. 67—Pierce; later; 1892. 68—Newton; 1892. 69—Hibbard; 1894. 70—Clapp; 1891. 71—Hill; older; 1883. 72—Hill; later; 1887. 73—Esty; older. 74—Esty; 1896.



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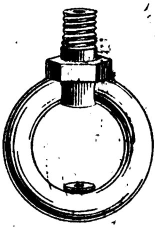

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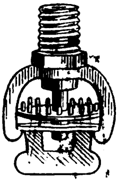

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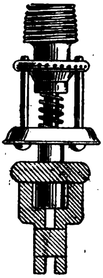

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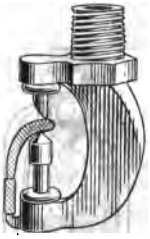

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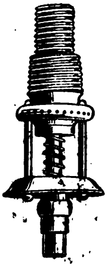

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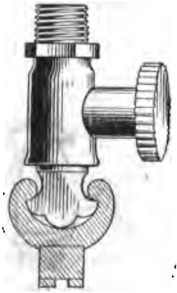

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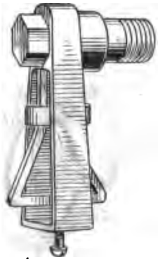

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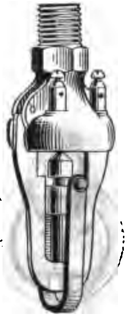
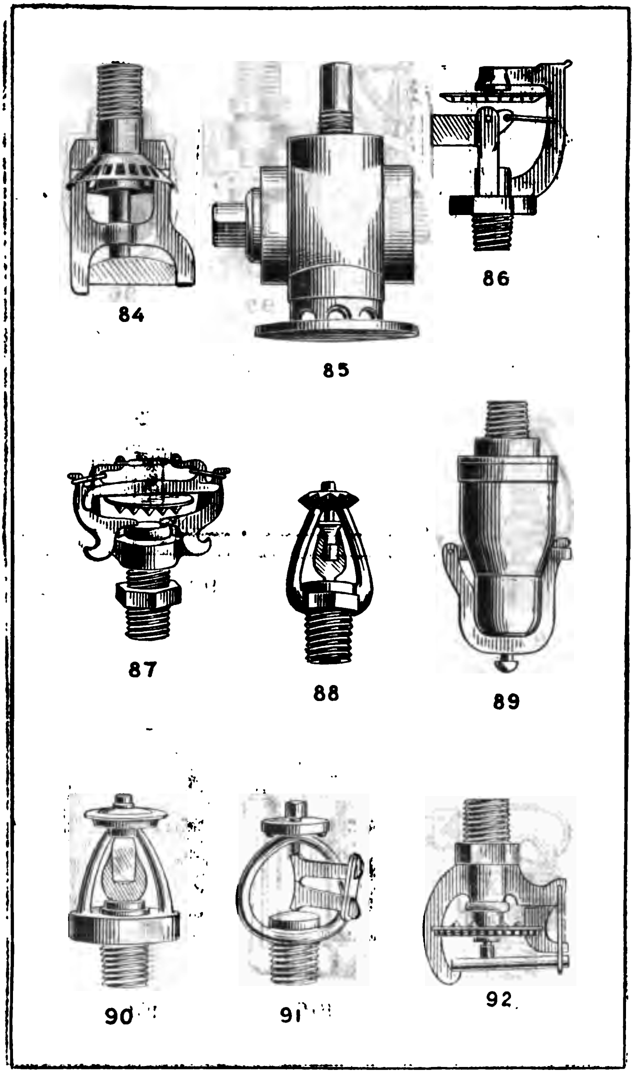
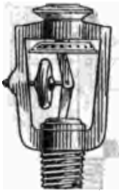


83

75—Babcock; 1900. 76—Buell; 1884. 77—Buell; 1892. 78—Bishop; 1888. 79—Buell; 1885. 80—Bishop; 1885. 81—New York & New Haven; elbow. 82—Buell; 1873. 83—Buell; 1884.



84—Burritt; 1883. 85—Draper Differential. 86—Clapp; 1887. 87—Kersteter; 1888. 88—Jahn; 1891. 89—John Kane; 1881. 90—Kersteter; 1898. 91—John Kane; 1900. 92—Nagle; 1891.



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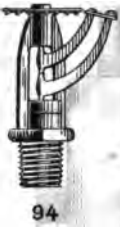

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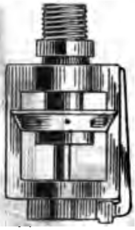

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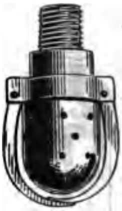

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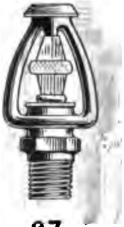

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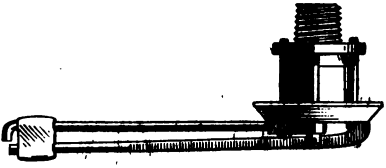

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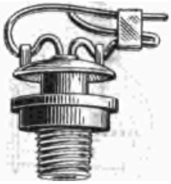

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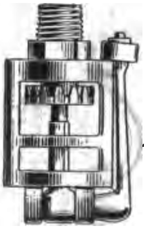

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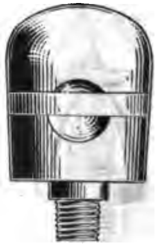
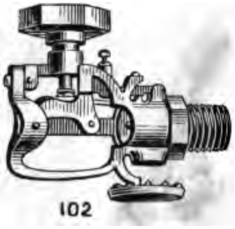


101

93—Naylor; 1895. 94—Swan; 1895. 95—Walworth, with soldered arm. 96—Talcott; 1882. 97—Up to Date; 1899. 98—Ruthenburg; 1885. 99—Mackey; 1883. 100—Walworth; 1898. 101—McLauthlin; 1894.



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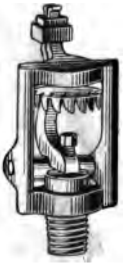

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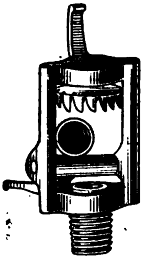

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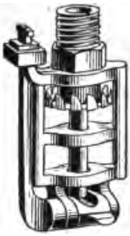

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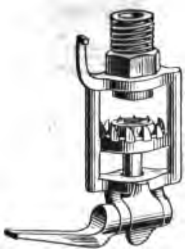

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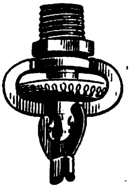

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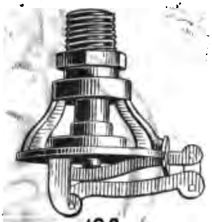

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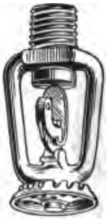

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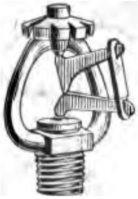
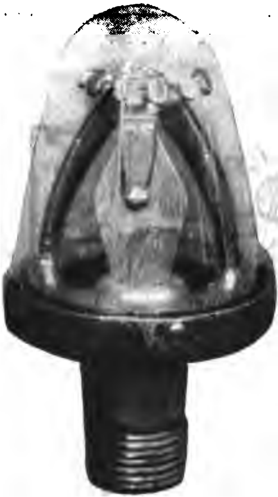
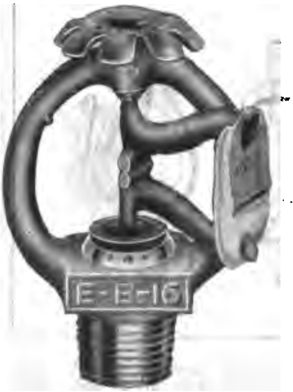


110

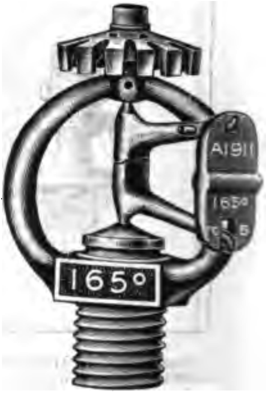
102—Shaffer Mascot; 1887. 103—Walworth; upright; closed. 104—Walworth; upright; open. 105—Walworth; pendant; closed. 106—Walworth; pendant; open. 107—New York & New Haven; vertical. 108—Star; 1886. 109—Independent. 110—Evans; 1902.



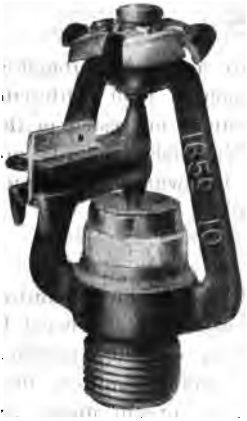
Grinnell Improved 1903 Sprinklers
(Glass Sealed)
General Fire Extinguisher Co.



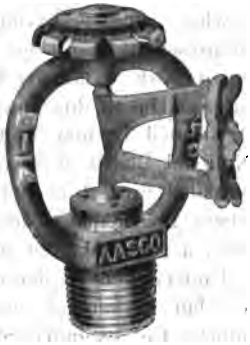
Evans, Issue B.
Merchants and Evans Co.



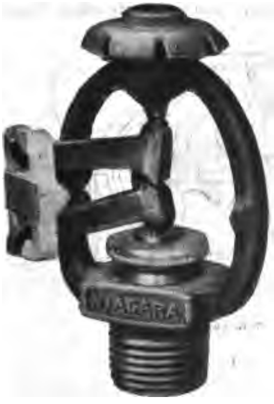
Crowder, Issue A.
Crowder Bros.



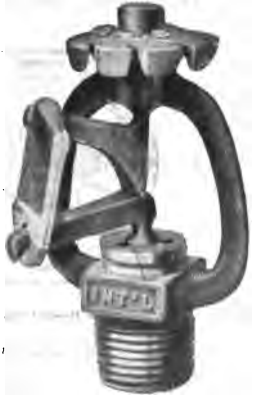
Manufacturers, Issue C.
Automatic Sprinkler Co. of America



Associated, Issue B.
Associated Automatic Sprinkler Co.



Niagara, Issue B.
Automatic Sprinkler Co. of America



International, Issue B.
International Sprinkler Co.

FIRE PUMPS

Uniform specifications for Fire Pumps are now used throughout the whole country, having been agreed upon in joint conference by representatives of the different organizations interested in this class of work. They are known as "The National Standard" and have been, up to this time, adopted by the following Associations:

Associated Factory Mutual Fire Ins. Co's.
National Board of Fire Underwriters.
National Fire Protection Association.

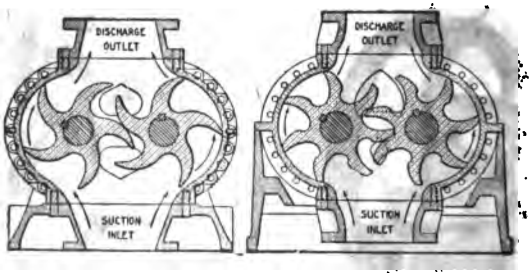
These specifications are followed by all the leading manufacturers; a few makes of pumps have been examined and listed by the Underwriters' Laboratories as complying with the specifications, but in general, manufacturers have not submitted their products for examination and underwriting organizations are accepting of any reliable maker the pump catalogued as an "Underwriters' Fire Pump."

The principal points of difference between a fire pump and the ordinary commercial pump are:

ROTARY FIRE PUMP

(a) The water passages are made larger than in most pumps hitherto built, so that there is less loss of pressure in getting water to and from the pump.

(b) The pump is "rust-proofed" so that it may start instantly after disuse,



5 Bucket Cam. **7 Bucket Cam.**

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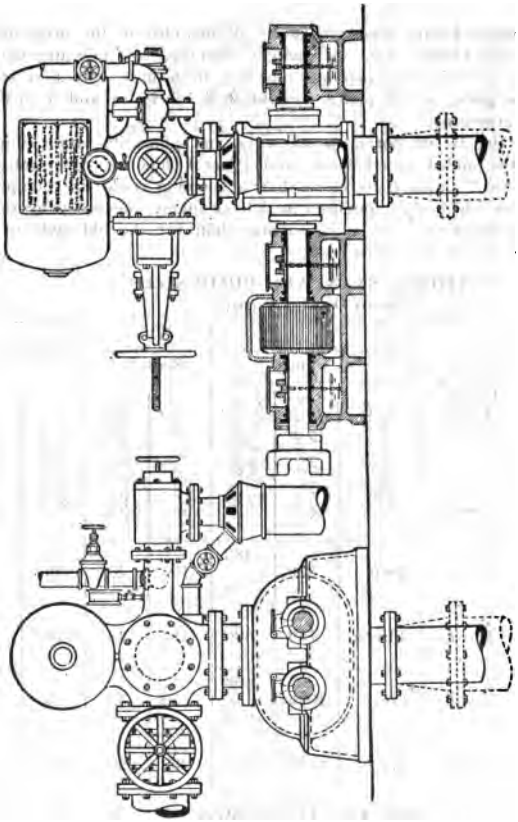
FIG. 88.—Rotary Pumps

by making its working cams and water casing of solid composition instead of cast iron.

(c) The shafts are made heavier and the bearings more liberal, with special arrangements for keeping these bearings oiled and in readiness for instant use.

(d) A single pair of forged steel gears is supported on each side. These are accurately cut and run in oil.



End Elevation.
Rotary Fire Pump. Type B.
(With Standard Fittings.)

Longitudinal Elevation and Section.
Rotary Fire Pump. Type B.
(With Standard Fittings.)

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FIG. 89

(e) A special discharge casting and air chamber with certain fittings is furnished with each pump. These fittings include a pressure gauge, a relief valve and cone, a priming pipe and valve, a starting valve, two to six hose valves, and a capacity plate.

STEAM DUPLEX FIRE PUMP

1. Its steam ports and water passages and air chamber are made much larger than in common trade pumps, so that a larger volume of water can be delivered in an emergency without water hammer.

2. It is "rust proofed" that it may start instantly after disuse, by making its piston rods and valve rods of Tobin bronze, instead of steel; its water pistons, stuffing boxes and rock-shaft bearings of brass, instead of cast-iron. Its valve levers are made of steel or wrought-iron forgings, or of steel castings.

3. The following necessary attachments are all included in the price of the "National Standard Pump," viz.:—a vacuum chamber, two pressure gauges, a relief valve, a set of brass priming pipes, 2 to 6 hose valves, a stroke gauge, a capacity plate, an oil pump, a sight feed lubricator and a cast-iron relief-valve discharge-cone.

By reason of the larger ports, passageways and pipes its larger number of valves, and the added attachments, and general superior construction a "National Standard" pump costs more than a common trade fire pump, but the cost per gallon which these pumps can deliver in an emergency by reason of their large passageways, etc., is no greater than for the old style of fire pump and is well worth this extra cost.

NATIONAL STANDARD PUMP SIZES
Steam Duplex Pumps

Pump Sizes			Ratio of Piston Areas	Capacity at 100 Lbs., at Pump			Boiler Power Required		Full Speed	
Steam	Water	Stroke	About	Number of 1½-in. Streams	Nominal Gals. per Minute	Actual Gals. per Minute	Horse Power	Steam Pressure at Pump, Lbs.	Revolutions per Minute	Piston Travel, Feet per Minute
14 x	7 x	12	4 to 1	Two	500	483	100	40	70	140
12 x	7½ x	12				520				
16 x	9 x	12	3 to 1	Three	750	806	115	45	70	140
18 x	10 x	12	3 to 1	Four	1000	999	150	45	70	140
18½ x	10½ x	12				1050				
20 x	12 x	16	2½ to 1	Six	1500	1655	200	50	60	160

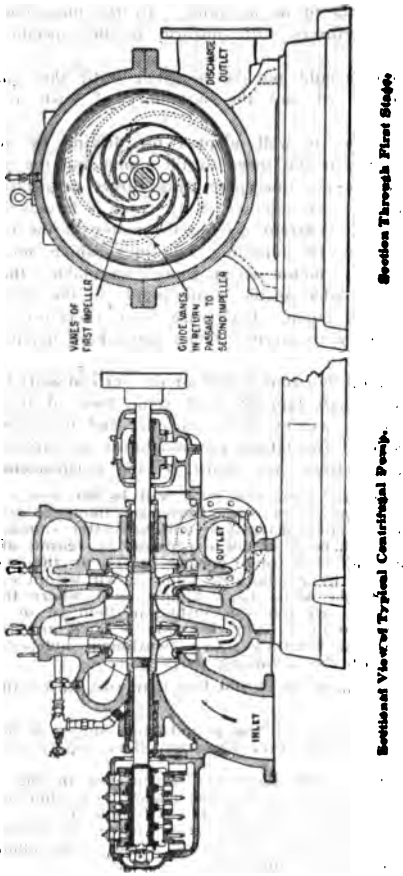
ROTARY FIRE PUMPS

Nominal Gallons per Minute	Approximate Width of Buckets	Approximate Distance Between Centers	Approximate Speed, Revolutions per Minute	Number of 1½-inch Streams	Approximate Horse Power Required for 100 Lbs. Pressure*
	Inches	Inches			
500	8	7 or 8	275	2	60
750	9 or 10	8 or 9	275	3	90
1000	10	9 or 10	250	4	120
1500	12	10 or 12	250	6	180

* Somewhat less horse power will drive the pump when spur gears are used and conditions are favorable.

CENTRIFUGAL FIRE PUMPS

Centrifugal pumps are those in which the water is given a high velocity by revolving impellers. The velocity of the water on leaving the impeller is reduced by suitably arranged passages and appears as pressure. Higher pressures may be secured by increasing the speed or by arranging two or more impellers in series. To avoid excessively high speeds the latter method is usually employed, forming the multi-stage pump.



Section Through First Stage.

Sectional View of Typical Centrifugal Pump.

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FIG. 90

It is the intent of these specifications to prescribe limits within which manufacturers may work to secure a pump comparable in reliability and efficiency with the present steam or rotary pump. High efficiencies, however desirable, should not be secured at the expense of simplicity and reliability under average fire-service conditions.

Although by these specifications it is expected to secure centrifugal pumps satisfactory for fire purposes, it is recognized that the art is in a progressive state, and experience may subsequently show some modifications from these requirements to be desirable. In the meantime, however, it is expected that manufacturers will conform to the specifications as herein printed.

Centrifugal pumps should not be accepted until the conditions in each case have been examined and the suitability of such a pump has been determined.

The centrifugal pump is well adapted for driving by an electric motor or by a steam turbine, as the speed of the pump and the prime mover may readily be made the same, thus permitting direct connection. Whether or not the motor drive may be accepted in any case is largely a question of the reliability of the electric current driving the motor in the event of a fire in the property itself, or in adjoining buildings which might threaten the property. To make a motor-driven pump acceptable, the electric power supply should be as reliable as the steam supply in the average property for the ordinary steam fire pump. Each case must, therefore, be specially considered and decided upon its merits. Other methods of driving, where reliable, will be acceptable.

TYPE.—(a) Either the horizontal-shaft or the vertical-shaft type may be used.

(b) If the vertical-shaft type be used, some form of thrust bearing must be provided to take the weight of the impeller and its shaft, and a separate thrust bearing provided for taking the weight of the driving shaft. Means must be provided to adjust each thrust bearing independently of the other.

It is probable that the horizontal type will be the less expensive and for many situations, will be preferable. There are likely to be, however, situations for which the vertical-shaft type will be better suited, such as a very high suction lift, or where it is not expedient, by reason of dirt and dampness, to place the motor or other prime mover at the same level as the pump. In such cases, by placing the pump down within easy reach of the water and extending the shaft to a higher level where the motor can be connected and better cared for, the outfit can then be made comparable in reliability to the horizontal type at low lifts. Such an arrangement would call for the two thrust bearings above mentioned, independently adjustable to take the weight of the revolving parts.

STAGES.—The pump must be of not less than two stages and not more than four.

To obtain a fire pressure of 100 pounds two stages at least appear to be necessary, in order to avoid very large impellers and to secure a reasonably good efficiency.

It is also recognized that there are advantages in the four-stage pump, permitting of lower speeds; and in some makes they admit of a more perfect balancing of end thrusts without the added complication of balancing pistons and thrust bearings. The four-stage pump being of smaller diameter, also permits of a stronger design of casting. One stage pump may be satisfactory when driven by steam turbines.

Whether one, two, three, or four stages are adopted, the utmost simplicity and ruggedness of design, together with the avoidance of all dispensable complications, will be required.

CAPACITY AND SPEED.—(a) The four standard sizes for centrifugal pumps will be as follows:

SIZE OF PUMP	
Gals. per Min.	No. 1⅛' Streams
500	2
750	3
1,000	4
1,500	6

(b) The speed of pump must not exceed 1,800 revolutions per minute.

Centrifugal pumps will be most frequently driven by electric motors, and it is desirable to bring their speeds into conformity with the larger number of standard motors now being built.

Somewhat higher speeds, not to exceed 2,500 r. p. m., may be allowed for pumps driven by steam turbines. But in such cases permission should be obtained from the inspection department having jurisdiction.

Steam turbines must be capable of driving pump at rated speed and pressure, with steam pressures varying from 75 to 150 pounds.

EFFICIENCY AND POWER.—The pump must be able to discharge its full rated capacity at its rated speed against 100 lbs. pressure, with substantially a zero suction lift, and at an efficiency not less than as given in the table following:

Size of Pump	Per Cent Efficiency
500 gallons per minute	50 to 55
750 " " "	55 to 60
1,000 " " "	60 to 65
1,500 " " "	65 to 70

The efficiency of centrifugal pumps falls away rapidly on the small sizes. These efficiencies are required, not because the cost of the power used during the fire is of importance, but because a much lower efficiency would mean a larger motor, consequently more first cost, and, when running, a larger tax on transmission lines and power stations.

The power required to drive these four different sizes of pumps at their full rated capacity, based on the required efficiencies, will be about as follows:

Size of Pump	Efficiencies	Horse Power Required
500 gallons per minute	50 to 55	64 to 60
750 " " "	55 to 60	88 to 80
1,000 " " "	60 to 65	107 to 100
1,500 " " "	65 to 70	148 to 138

The theoretical power required to discharge 250 gallons a minute at a pressure of 100 lbs. and with a zero suction lift, is 14.6 horse power. For a pump of 60 per cent efficiency this would mean that an input to pump of about 25 horse power would be needed per 250 gallons per minute delivery at 100 lbs. pressure. For efficiencies other than this or for any material suction lift or head, some modification in horse power required will be demanded. In any event the power provided should be sufficient to guard against any appreciable overload of the motor at the rated discharge in pressure.

CHARACTERISTIC CURVES.—(a) The design of the impeller blades must be such that it will not be possible to overload the driving motor more than 25 per cent.

Electric motors ordinarily will be used for driving pumps of this type. It is important to have the pump so designed that the motor could not be burned out, either by shutting off streams or by connecting more streams than the rated capacity of the pump. Motor builders are ready to guarantee their motors against overload of 25 per cent for 2 hours. A greater overload than this should not be maintained except momentarily.

(b) For pumps driven by a constant speed motor a steep characteristic curve should ordinarily be adopted as shown in Figure 91.

The wide range of pressures and capacities obtainable from a steam fire pump are not possible with a centrifugal pump driven by a constant speed motor. Some compromise, however, is feasible by the adoption of a steep characteristic, whereby a much high pressure than the rating is possible at the smaller flows, as indicated in Figure 91. This higher pressure is very desirable where long lines of hose are required, or in the event of a fire in a very high or wide building.

In those instances where pumps take their water supply under a considerable head, the steep characteristics should not be adopted; or, in any event, one so steep as to result in excessive pressures on the yard system.

(c) For pumps driven by an adjustable speed motor or prime mover, a flat characteristic curve should ordinarily be adopted as shown in Figure 92.

The higher cost of such adjustable speed pumping units have usually prevented their adoption. But their obvious advantage in many instances makes their selection well worth while.

(d) **For pumps taking their water under considerable head, the flat characteristic curve should ordinarily be adopted, or one which will not in conjunction with the inlet pressure result in unduly high pressures on the fire system.**

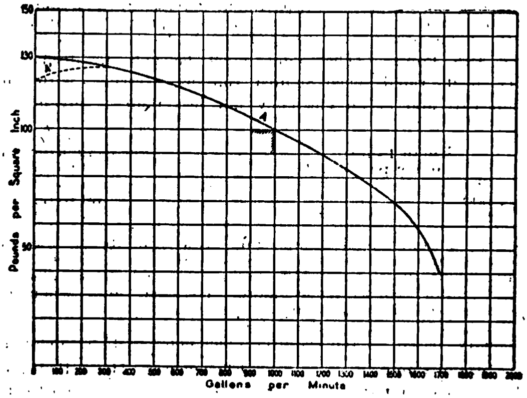

FIG. 91

Centrifugal pumps are being extensively used in cities as "booster" pumps, taking their water supply from the street mains at pressures from 20 to 50 pounds.

With the steep characteristic curve shown in Figure 91, there might result undue pressures on the fire system at the smaller flows.

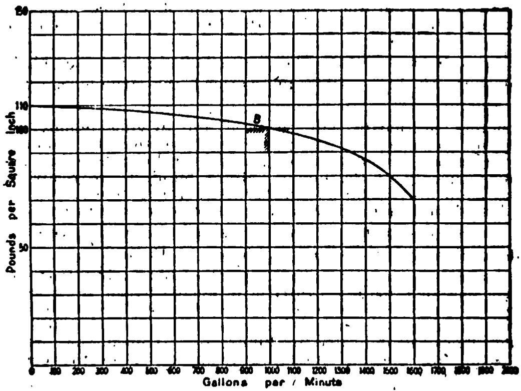

FIG. 92

If the inlet pressure is to remain nearly constant, pump impellers can be designed to suit, and high pressures avoided. However, as these pressures are sometimes reduced materially under large flows, no allowances for this suction head should be made, unless assured that it is of a constant character.

For these reasons the flat characteristic curve will ordinarily better safeguard the fire systems, and if the situation demands higher pressures, the adjustable speed motor or steam turbine should then be adopted.

In any installation where unduly high pressures result, and the above suggestion cannot be adopted, the relief valve should be set at some reasonable safe pressure, say 125 lbs., and allowed to discharge the excess capacity at the smaller flows.

There have been a few pumps built of the 3 stage type, operated by a constant speed motor, that permit variable pressures. Ordinarily only two of the impellers are running, giving pressures of 90 to 100 lbs. But by throwing into commission the third impeller, pressures 35 per cent to 40 per cent higher are available. In some cases, such equipments would satisfactorily meet the conditions mentioned in e.

(e) For a constant speed the characteristic curve of pressure and capacity must be one constantly rising as the discharge decreases.

At no point in this curve should the pressure be higher than at the shut-off point.

As the pressure gauge is the only indicator of the pump discharge, it is important that this gauge should indicate only one discharge capacity for any given pressure and speed.

(f) For a constant speed and a steep characteristic curve, the pressure at shut-off point should be not less than 30 per cent higher than pressure at rated capacity, and the discharge capacity should be 50 per cent higher than rated discharge at a pressure not less than 70 per cent of that at rated discharge.

INSTALLATION OF PUMPS

LOCATION.—Pumps must be so located as to secure the following features.

(a) They must be safe from damage from falling floors or machinery, and by suitable cut-offs be safeguarded from any influence such as smoke, fire or flood that might drive away the operator. A one-story building isolated from the main group is to be preferred.

Where brick or reinforced concrete is not feasible, expanded metal and cement is recommended as an inexpensive and desirable construction for such a room.

The practice of locating centrifugal pumps in basements not cut off but with pump arranged to start from outside of building is not desirable, and if used care must be taken that all starting devices, priming valve and all other similar valves be arranged to be operated from the same point.

Where there are several pumps in different buildings not all subject to one fire, the requirement concerning cutting off of pump may sometimes be waived.

(b) The pump room must be of ample size to afford access at all times for operating and overhauling. It should not be used for miscellaneous storage.

(c) Its location must permit of practicable pipe connections, the suction pipe receiving first consideration.

(d) Some means must be provided for maintaining the temperature of pump room above the freezing point.

Artificial light must be provided, and provision made for drainage and ventilation.

A lantern, preferably two, with safety matches should be kept in pump room.

FOUNDATION AND SETTING.—(a) Fire pumps must be placed upon solid foundations, preferably built of concrete or, if desired, of brick laid in strong hydraulic cement.

It is desirable to give these foundations a batter fore and aft of about 1 to 4 in order to secure ample bearing upon the sub-foundation. This will insure stability during the fast running demanded of fire pumps. Where foundation is built of bricks, a capping of stone or cast iron under bed plate is an advantage in tying together the upper part of the foundation.

In some cases it may be necessary to support the pump on I-beams or a framework of structural iron. The bed plate should then be bolted securely to the beams.

(b) Pumps must be set level, with foundation bolts in position, and the joint between the foundation and the bedplate must be made solid by grouting with thin, pure cement. When thoroughly set, the bolts should then be tightened up.

(c) Care should be taken not to spring bedplate, thereby throwing out of line the respective shafts of motor and pump. The interposed flexible coupling will take care of only slight inaccuracies in alignment.

SUCTION SUPPLY.—An inexhaustible supply of water is to be preferred. Where a stored supply only is available, it should be large enough to supply the pump for two hours, more or less, depending upon local conditions. Some reliable means should be provided for filling such reservoir through a 4-inch or 6-inch pipe.

SUCTION PIPE.—(a) Where the pump takes its water under a head, suction pipe may be of the same size as opening in pump; but with a suction lift of 10 feet or more, and a length of pipe exceeding 30 feet, or with more than two elbows, suction pipe two inches larger must be used, and a special reducing casting must be provided to connect this pipe with the pump.

(b) A short suction pipe, if well supported, should preferably be of flanged pipe with rubber gaskets. If of some length and in yielding soil, bell-and-spigot pipe should be used, and the joints filled with lead and tightly calked. Yarn and similar materials should not be used as a substitute for lead in suction pipe joints.

(c) Great care should be taken in laying the suction pipe, so that it shall have a constantly ascending grade from the water supply to the pump.

If high places or summits are permitted, they are likely to give constant trouble by the accumulation of air, thereby cutting down the area of the pipe and reducing the amount of water possible to be delivered at the pump.

(d) Extremely long suction pipes should be avoided wherever possible. When exceeding 100 feet, effort should be made to provide an intake well as near as practicable to pump and supply the well through a large tile pipe laid on a down grade from the source of water supply. This inlet pipe should be provided with a gate valve.

FOOT VALVE.—Except with duplex pumps, with less than 18 feet lift, all situations involving a lift require a foot valve Any foot valve that may be installed should have bronze seats and be faced with some suitable yielding material, such as leather, and should be of a design and construction that will not unduly restrict the flow of water toward the pump. The foot valve should be so located as to be readily accessible and be provided with handholes.

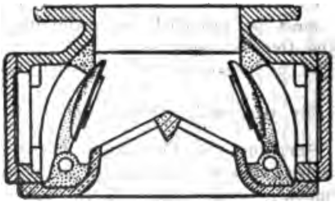

FIG. 93.—A Foot valve of Good Design

(f) Wherever a strainer is advisable, it should be so constructed and arranged that it can be cleaned or repaired without disturbing the suction pipe itself. A brass or copper wire screen of about one-half inch mesh and No. 10 B. & S. wire, secured to a frame sliding vertically at the entrance to the intake, makes a serviceable arrangement, and permits of ready cleaning and overhauling. The screen should have an effective area of one square inch for every rated gallon per minute size of pump. Double screens are advised, so arranged that either can be removed for cleaning while the other remains in service. The ordinary combination foot valve and strainer should be avoided.

(g) Where the pump takes its water under a lift, the suction pipe must not be used to supply any other pump.

DISCHARGE PIPE.—An approved indicating flanged gate valve should be placed in the discharge pipe and located next to the pump. There should also be in this same pipe a check valve located preferably outside of the pump house in the ground. If the valve is located inside the pump room it should be as near the building wall as possible, and, in any event, the valve and the pipe from it to the outside system should be thoroughly protected against injury.

By placing the discharge valve at the pump, any accident to the discharge piping, either in the pump room or outside, will not cripple the pump, for by closing the valve the pump will still be available for service through hose lines connected to the hose valves on the pump.

Unless the check valve in the discharge pipe is well protected against breakage, an accident to the pump or piping in the pump room may also damage the check valve, in which case the water from the other supplies may be seriously wasted.

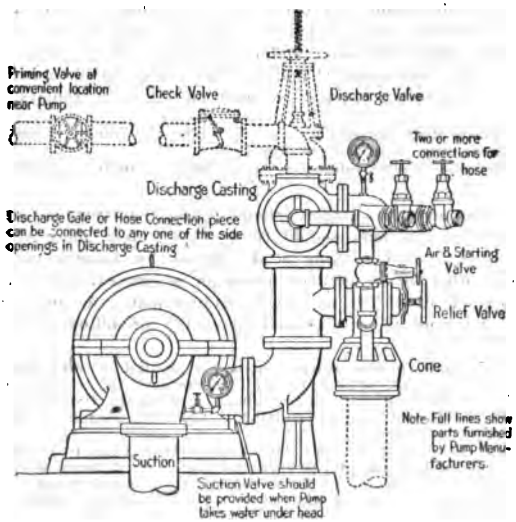
Priming Valve at convenient location near Pump
Check Valve
Discharge Valve
Two or more connections for hose
Discharge Casting
Discharge Gate or Hose Connection piece can be connected to any one of the side openings in Discharge Casting
Air & Starting Valve
Relief Valve
Cone
Note Full lines show parts furnished by Pump Manufacturers.
Suction
Suction Valve should be provided when Pump takes water under head

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FIG. 94

RELIEF VALVE WASTE PIPE.—The relief valve waste pipe should preferably pass directly from its discharge cone to the atmosphere. If connected to any underground drain, care should be taken that no steam drains enter near enough to work back through the cone and into the pump room. The waste pipe should be run the full size called for by the outlet of cone, and if more than one elbow is employed the next size larger pipe should be used to complete the connection. This waste pipe may at times be called upon to carry the entire discharge of pump at full speed.

When the supply of water is limited, as from a special suction reservoir or cistern, the waste pipe must drain into such reservoir or cistern, entering as far from the pump suction as is necessary to prevent the pump from draughting air which may be carried down into the cistern by the discharge from the waste pipe.

Size of waste pipes to be as follows:

Size of Pump	Size of Waste Pipe
500-gallon	5"
750-gallon	6"
1,000-gallon	7"
1,500-gallon	8"

PRIMING.—Pumps should preferably take their suction supply under a slight head; centrifugal pumps have no lifting ability until primed, and rotary pumps may get in this condition. Where this is not practicable, some kind of priming equipment must be provided. For this purpose one of the following methods is recommended:

(a) Provide a priming tank of capacity at least three times the volume of the pump and suction pipe (in no case less than 250 gallons). Connect tank to the discharge side of pump at such a point as will insure that all priming water enters the pump, and is not wasted in the pipes leading from the pump. This connection should include a straightway outside-screw-and-yoke valve and a swing check valve with pipe sizes as follows:

Size of pump (gals. per min.)......	500	750	1,000	1,500
Size of priming pipe for suction pipe not over 25 feet long.......	2½ inch	3 inch	3½ inch	4 inch

For longer suction pipes, larger priming connections may be advised.

The bottom of this tank should be at least 2 feet above the top of the pump to insure a good working head. Means for keeping tank filled must be provided, either by an auxiliary pump, or a connection to a public supply through a good sized ball and cock arrangement. A connection between fire pump and tank is also advised to permit of filling same at close of any test.

Where an ample public water supply is available, and the liability of freezing is not present, it will be well to connect this supply direct to discharge side of pump with a swing check and valve, thereby maintaining a filled system ready for instant starting. This, of course, is in addition to the tank above specified.

The liberal priming tank and large connecting pipe is necessary so that the pump could be primed, and primed quickly, even if there were considerable leakage at the foot valve. As the priming arrangement is so vital a feature to the successful starting of the pump, a considerable factor of safety is needed.

(b) Where the conditions warrant, such as an unusually long suction pipe, a small centrifugal pump driven by a separate motor or other power may be installed, preferably with the pump submerged, and its discharge connected between the main fire pump and its discharge check valve. This will enable the entire main suction pipe, including the pump, to be completely filled prior to the starting of the main pump. For such an outfit, in case it is not practicable to submerge the priming pump, a moderate-sized tank must be provided for priming it, arranged as outlined in paragraph a.

Such an arrangement would not be advised for short suction pipes and low lifts, as the method described in "A" would be better suited for such places.

(c) Where a reliable steam supply or separate water supply under good pressure is available, a liberal-sized exhauster or siphon ejector may be connected up between the pump and discharge check valve.

Such an arrangement has been successfully employed in exhausting the air from pump and suction pipe and permitting a prompt starting up of the main pump.

(d) Some type of mechanically operated exhauster may be provided, driven by a sparate motor so designed as to quickly pump the air out of the suction pipe and pump.

The exhauster should be connected between pump and discharge check valve, so as to completely fill suction pipe and pump. A gate valve should be placed in this exhauster connection, of approved indicating type, to be closed as soon as pump is primed.

Driving Connections

The best method of driving a rotary pump will depend upon the conditions present at a given situation. The following methods may be used, and the conditions governing their adoption are indicated.

PUMP SHAFT CONNECTED TO AN INDEPENDENT SOURCE OF POWER.—(a) This involves a separate water wheel motor or other prime mover of ample power running at the same rated speed of pump. No clutch is necessary, but some form of coupling, to allow for slight end play of shaft is needed, thereby preventing end thrust of cams on pump casing and a resultant wear. This makes the preferred arrangement.

(b) If speed of prime mover is not the same as the rated speed of pump, cut spur gears, or a silent chain drive may be employed to secure the desired speed. Such gears should be kept in mesh at all times. No clutch or coupling is necessary.

(c) If an electric motor is the source of power, the motor and pump should be bolted rigidly to the same bed plate.

PUMP CONNECTED THROUGH SPUR GEARING TO THE MAIN SHAFT OF THE MILL WATER WHEEL.—(a) In this case some form of clutch of the rim friction type should be used between the driving gear and the wheel shaft. A silent chain drive can also be used in place of the gears, being specially useful in cases where the pump cannot be located near enough to main shaft to permit spur gears of reasonable diameter. The chain drive should not be used in wet places.

Under some conditions the plain square jawed clutch may be used in place of the rim friction clutch, where other reliable and independent pumps are available on the same system.

The old type of sliding spur gears, formerly used to some extent, is not advised, as there is always the danger in the excitement of a fire of throwing the gears into mesh while power is running, and stripping the teeth.

PUMP CONNECTED THROUGH A PAIR OF FRICTION GEARS TO THE MAIN SHAFT OF THE MILL WATER WHEEL.—(a) This method is probably the most common in use. The gears are simple and inexpensive, and when properly fitted up will give fairly good service. They have the advantage over spur gears in that they can be thrown into mesh while power is running. They are not so efficient, however, being liable to slip, and consume power by being pressed tightly together. There is a tendency for such gears to get out of line due to axial movement of wheel shaft. Flat places are sometimes worn on their periphery, decreasing their efficiency. To be acceptable careful attention should be given to the following features:

(b) The gear on main shaft should be truly centered by giving, when possible, its finishing cut after being keyed on to a shaft.

CENTRIFUGAL PUMPS will probably be driven by electric motors in most cases, though any reliable form of prime mover may be adapted to the service. The preference will naturally be for such driving methods as permit of a direct connection without speed-changing devices. With motor driving the main question will be the reliability of the current supply, and this can be determined only by a careful study of the conditions in each case.

Where the speed of motor or prime mover is not the same as pump speed, the transmission may be either by a single pair of cut spur gears, preferably of the herring bone type, or a silent chain drive of approved construction.

TESTS FOR ACCEPTANCE

Steam Duplex Pumps

TEST FOR SMOOTHNESS OF ACTION.—a. Provide outlets for the water; start the pump slowly, gradually open steam-throttle to bring the pump to full speed. The pump should run smoothly at the rated full speed of 70 revolutions per minute (or 60 revolutions if a 1,500-gallon pump) with full length of stroke, and meanwhile maintain a water pressure of 100 pounds per square inch.

If the hose lines are short, or discharge is too free, partly close the water outlet valves, thus throwing an extra back pressure on the pump equivalent to that which would be produced through a greater length of hose.

During this trial it is preferable to discharge the water through lines of 2⅝-inch cotton rubber-lined hose, preferably each 150 feet long, each connected directly to the hose outlets on the pump, and each line having a 1⅛-inch smooth nozzle at its outer end. Two lines should be connected for a 500-gallon pump, three for a 750, and so on, having as many lines as rating of pump requires.

A hose line 150 feet long, with an inside surface of average smoothness, and with a 1⅛-inch nozzle attached, will require about 80 pounds pressure at the pump to discharge 250 gallons per minute, and the nozzle pressure will be about 45 pounds. Therefore, with lines attached as above, a pressure at the pump of about 80 pounds should represent a discharge about equal to the rated capacity of the pump, and would ordinarily correspond with the rated full speed revolutions.

If the pump runs smoothly under these conditions, it is well to open the throttle somewhat further, and bring the pressure at the pump up to 100 pounds. This will give a discharge of about 280 gallons per stream, or about 12 per cent in excess of the rated capacity. The revolutions will, of course, correspondingly increase, and under all ordinary conditions a pump should run smoothly at this higher capacity, though a little more vibration and pounding would be expected than when running simply at its rated speed.

After cushion valves are adjusted there should be no noteworthy water hammer or valve-slam. Sometimes valve-slam is not the fault of the pump, but arises from an obstructed suction pipe. It is objectionable to doctor water hammer in a pump by snifting air into the suction, as this cuts down the efficiency and is a poor expedient.

The quietness of that part of the hose near the pump, or its freedom from rubbing back and forth crosswise an inch or more with each pulsation of the pump, is a good index of the pump maker's skill in securing uniform delivery. Bad pulsation quickly wears holes in the hose, and to reveal this is the object of testing with hose connected directly to the pump.

TEST OF THE INTERNAL FRICTION.—a. This is shown by the reading of steam chest gauge compared with water pressure gauge at air chamber.

Tests have generally run about as follows, for pumps running at full rated speed:

Size, Gallons per Minute Capacity	Ratio of Steam Piston Area to Water Piston Area	Water Pressure, Lbs. per Sq. In.	Steam Pressure Theoretically Necessary, Disregarding Friction	Excess of Steam Pressure Needed to Overcome Friction, Back Pressure, etc.	Actual Steam Pressure Found Necessary at the Pump
500	4 times	100	25	15	40
750	3 “	100	33	12	45
1,000	3 “	100	33	12	45
1,500	2¾ “	100	36.5	13.5	50

b. The steam pressure needed will vary slightly with the freedom of the exhaust pipe and with the tightness of the packings, etc., but a steam pressure of 45 pounds at the steam chest should suffice for 100 pounds water pressure on pump in proper adjustment.

TEST OF STRENGTH AND TIGHTNESS.—a. First, shut the main valve between the pump and the fire system to avoid possible injury to joints or fittings, thus shut all water outlets nearly, but not quite tight, so pump will move very slowly. Screw safety valve down hard. Slowly and carefully admit steam pressure sufficient to give 240 pounds per square inch water pressure.

b. With this extreme pressure all joints should remain substantially tight, and the slow motion of the pump should be tolerably smooth and uniform. (The leakage of a few drops here and there and a little unsteadiness of motion are to be expected.)

c. If boiler pressure is above 85 pounds, the safety valve on pump should be attached and screwed down only enough to hold the required pressure. For with 100 pounds or more of steam the water pressure might be carried too high.

After completing the above test slack off on safety valve, setting it so that it will begin to open at about 100 pounds pressure.

TEST OF CAPACITY OF RELIEF VALVE.—a. The relief valve may next be tested by first adjusting it to pop at 100 pounds, then shut the main outlet to pump, and then shut the hose gates one by one, and thus force all the discharge through the relief valve, meanwhile opening steam throttle, so as to run pump first at two-thirds speed or about fifty revolutions per minute, and finally at full speed (seventy revolutions). The safety valve (relief valve) should carry all this and not let the pressure rise above 125 pounds.

The pressure in a quick-moving fire-pump necessarily fluctuates 5 to 15 pounds at different points in stroke, and an air chamber of reasonable size cannot wholly remove this. Therefore the safety valve must be set at about 15 pounds higher than the intended average working pressure; otherwise it will get to jumping with almost every stroke.

TEST OF INTERNAL LEAKAGE OR SLIP.—a. Set safety valves at 115 pounds, shut all water outlets, admit steam enough to give 100 pounds water pressure, then pump will move very slowly under the influence of the leakage past plungers; about one revolution of pump per minute shows a proper accuracy of fit. Anywhere from one-third to two revolutions per minute is satisfactory.

Too tight a fit is bad, as if not exceedingly uniform it induces scoring or fretting of the metals. Moreover, should pump happen to be run dry for a few minutes before catching its suction a slight warming and expansion of the plunger may cause it to stick and fret.

TEST WITH MAXIMUM WORKING PRESSURE.—a. For this, alternately shut down the main outlet gate and adjust the hand-wheel of the safety valve, and open up on the throttle as may be required, running pump at say one-half speed (or, in experienced hands, at full rated speed), and note the greatest water pressure which the full boiler pressure (unless boiler pressure is above 85 pounds) will yield with pump at full speed.

Sometimes it may be necessary to force water through very long lines of hose, or to an unusual height.

Steam fire engines are not infrequently called on to give 200 pounds per square inch water pressure.

To test short hose lines with anywhere near so high a pump-pressure is dangerous, lest the nozzle kick and pull itself away from the man holding it and thresh around; but the ability of the pump may be tested by putting this high-pressure delivery mainly through the safety valve, or in part through the partially closed main outlet gate.

It is not advisable to carry this water pressure above 200 pounds in the field test, although in the shop test the water pressure is carried to 240 pounds, and engine driver should stand with his hand on the throttle.

TEST FOR MAXIMUM DELIVERY.—a. This can best be tried by adding one or, in some cases, two more streams than the pump is rated to deliver by attaching the extra lines of hose to some hydrant near, and then speed up the pump gradually, to see how fast it may be run before violent pounding or slamming of valves begins.

Sometimes the increased delivery can be drawn off through an open hydrant-butt meanwhile holding sufficient back pressure to show 100 pounds on the water gauge by partly closing the discharge valve.

The engine driver should stand with his hand on or near the throttle when thus speeding the pump.

It is all right to run a fire-pump up to the utmost speed possible before water hammer begins, and very often a pump, while new and if favorably set up, can deliver 25 to 50 per cent more than rated capacity; nevertheless, although expert treatment can force 1,000 gallons from a 16 x 9 x 12 pump we can rate it as only a 750-gallon pump. There must be some margin to allow for wear and for the possible absence of the expert at time of fire.

Rotary Pumps

Tests similar to those for duplex pumps should be run for: Smoothness of action; maximum working pressure; maximum delivery, and capacity of relief valve.

Centrifugal Pumps

(a) The pump must be able to discharge its full rated capacity at 100 lbs. pressure at the pump, assuming a zero suction lift, and maintain this condition indefinitely without objectionable heating of bearings or at motor, or exceeding the rated power of the motor and with an efficiency not less than specified.

The efficiency of pump for any delivery is to be based on the electrical H. P. output of motor and the hydraulic H. P. output of pump. For a D. C. motor this power output is to be computed from the readings of voltmeter and ammeter, allowance being made for motor efficiency.

For an A. C. motor this computation will of course involve the consideration of the power factor of the circuit.

(b) Shut off one stream after another until all are closed, and note the quantity delivered, and the pressure at the pump under the different conditions. Also note the power required and compute the efficiency for the several points.

(c) Put on one or more streams in addition to the number for which the pump is rated, and note the quantity delivered and the pressure, also the power required under this excessive discharge, and compute the efficiency. Under this test the pump should work with entire smoothness, and the motor should not be overloaded more than provided for by Article No. 43a.

(d) If provision is made for varying the speed of the motor, try the motor at different speeds under conditions which would be likely to be met with in case of fire, noting quantities and pressures, and compute efficiencies. Under all conditions the motor and pump should run smoothly and without trouble in any part which would prevent continuous running, should occasion require it.

(e) Let all water out of the suction pipe, note the lift, and make several tests to determine how long it takes the priming apparatus to get the pump again into service. Especially note whether the pump shows any sign of heating or other distress where the priming equipment requires it to be run a short time before it is flooded with water.

The pump to be acceptable must meet all these tests satisfactorily and in accordance with the requirements of the specifications.

REQUIREMENTS FOR ELECTRICAL DRIVING AND CONTROL OF FIRE PUMPS

Before installing an electrically driven pump the matter should be taken up with the inspection department having jurisdiction in order that an investigation may be made to determine whether the reliability of the current supply is such as to make the electric service dependable. The question of reliability of the service depends on so many factors that in many cases it can only be settled on the ground.

All details of construction, materials and apparatus pertaining to the electrical equipment, except as modified or provided for by these requirements, must comply with the requirements of the National Electrical Code.

POWER STATION.—(a) When current is taken from a single power station the station must be of non-combustible construction, so located or protected as to be free from chances of serious damage by exposure from fire, and the design and arrangement of apparatus within it such that there will be but little chance of interruption of service.

(b) Where current is taken through a substation, this substation must also meet the requirement of Section a, and in addition the number and arrangement of cables between the station and the substation must be such as to practically guarantee continuous power at the substation.

(c) Where service cannot be obtained from a power station or substation meeting these requirements, it must be obtained from two or more stations or substations so located and equipped that an accident or fire at one will not cause an interruption of the service supplied by the others.

A private generating plant located on the premises served by the fire pump, if in a separate power house or cut off from main buildings, will be considered as a power station, and may be used as one source of current supply.

TRANSMISSION LINES.—(a) The lines between the power plants and the pump room must be of such number, so arranged and so located that there will be small chance of an interruption of service to the motor, due to accident to the lines. All wiring in the pump room must be in approved conduit.

Where the values involved are large and the crippling of this pump service would seriously affect the protection of the property, at least two separate lines from the power plant or plants to the pump installation must be provided. The lines must be run by separate routes or in such manner that a failure of both at the same time will be only a remote possibility.

Where current is taken from an underground Edison 3-wire system it will be considered that two independent lines have been provided if connections are brought into the pump room from two street mains or feeders not terminating directly in the same junction box.

A complete underground circuit from generating station to pump is strongly recommended and should be obtained when practicable. When such construction is not available, an overhead circuit may be allowed, but that part of the circuit adjacent to the plant or exposing plants must be run with special reference to damage in case of fire. Where the pump room is a part of, or in close proximity to, the plant which the pump is designed to protect, the wires for some distance from the pump room must be underground.

(b) Each line between the power plant and pump room must be of such size that its safe carrying capacity, as given by Rule 18 of the National Electrical Code, will not be exceeded by the load carried.

Where direct current motors are used, the voltage at the motors must not drop more than 5 per cent below the voltage rating of the motors when the pumps are being driven at rated output, pressure and speed, and the lines between motors and power stations are carrying their peak loads.

When alternating current motors are used, the voltage at the motors under these same conditions must not drop more than 8 per cent below the voltage rating of the motors.

(c) The overload protective devices at the power plants, and where provided at various points on the lines, must be of such rating and so set that they will open the circuit only under short circuit conditions.

Approved fuses may be used, if desired, except for the protection of the pump motor where circuit breakers are required. The fuses, however, must be of such size that an overload or short circuit at the motor or its control apparatus will not cause them to open the circuit, but instead, the circuit breaker protecting the motor.

TRANSFORMERS.—(a) Must be located in a separate non-combustible, well-ventilated building or room thoroughly cut off from other buildings or rooms. Access to room must be from the outside of the building. Transformers may be located outdoors by special permission where conditions are favorable.

(b) Transformers supplying current to the lights and motors in the buildings served by the fire pump may also supply the pump motor, provided all load except the pump motor load can be quickly cut off when necessary. Switches for doing this must be in the pump room unless transformer room is near pump room, in which case they may be in transformer room.

(c) Room containing transformers installed solely for the purpose of supplying current to a pump motor must be dry and heated in cold weather, or else the transformers must be normally left connected to the supply lines.

MOTOR.—(a) Direct current motors must be of the shunt wound type.

Alternating current motors must be of the wound motor or squirrel cage induction types. The squirrel cage motor must be used only when the conditions are such that it will surely start and attain full speed.

This will prevent the use of the squirrel cage motor with pumps of the positive displacement types such as rotary and plunger pumps, and will require that the electric service be such that the heavy starting current will not cause the voltage to drop sufficiently to prevent the motor starting.

(b) Motor must be of such capacity and design that at rated voltage its full load ampere rating will not be exceeded when the pump it drives is delivering its rated output at specified pressure and speed, and when running under this load for eight consecutive hours followed by an overload of 25 per cent for two hours, and an overload of 50 per cent for one minute, the rises in temperature at its various parts above the temperature of the surrounding air must not exceed those recommended in the standardization rules of the American Institute of Electrical Engineers. No electrical nor mechanical weakness should develop during these tests.

(c) Motor and control apparatus must be protected from water coming from possible leakage, or breakage of any connection at the pump or other piping in its vicinity, including hose lines which may be connected to the pump.

This can probably be best accomplished by the erection of a non-combustible partition between motor and pump, extending from floor to ceiling, and laterally sufficiently far to protect the motor and other electrical apparatus not otherwise protected. Such an arrangement will permit the use of the open type of motor, and for most situations will prove the least expensive. The enclosed type, with fan or blower system may be used, but preference is given to the arrangement described.

(d) Motor windings should be thoroughly impregnated with waterproofing compound.

Controlling Equipments

The following specifications cover the construction and installation of controlling equipments of both the manual and the combined manual and automatic types for electric motors driving fire pumps.

Before plans are completed for such equipment the inspection department having jurisdiction should be consulted as to whether the manual or the combined manual and automatic type will be acceptable for the proposed installation, and also with reference to the location of the controlling equipment and its enclosures or protection against mechanical injury.

In materials, details of construction, test and installation, except as modified or supplemented by these requirements, all parts of the equipment must comply with the requirements of the National Electrical Code.

All equipments must be specifically approved for fire pump controlling purposes.

Construction

DESIGN.—(a) The design of all parts must be such as to secure simplicity, strength, durability and ease of operation.

(b) All parts must be mounted on one or more panels of slate or marble, supported in a substantial manner on an iron frame, and the entire equipment must comply with the requirements for switchboards in the National Electrical Code.

(c) All parts, such as bearings, cams and latches, the operation of which is liable to be interfered with by corrosion, must be made of phosphor bronze or similar metal, except where magnetic qualities are essential. Springs must be of phosphor bronze or similar metal, or protected against corrosion in an approved manner.

OPERATING MECHANISM, MANUAL TYPE.—(a) The operation shall be such that the motor is directly started by a single lever, which, except in auto starters or compensators, shall be arranged to move in one direction from the initial to the final position.

(b) Electrical actuating devices will not be approved.

(c) Devices must automatically return to the off position in case of failure of voltage or in case the operator releases the handle in any but the full running position.

(d) Where direct current is used, an auxiliary field resistance may be provided which can be used to increase the motor speed 10 per cent.

RESISTANCES.—Starting resistances must be, unless inside of the motor, of the grid type, and comply with the requirements for tests of starting duty rheostats as given in the National Electrical Code.

AUTO STARTERS OR COMPENSATORS.—Must comply with the requirements of these rules and also with those of the National Electrical Code for the construction of auto starters.

OVERLOAD PROTECTION.—(a) Each motor lead must be protected by a circuit-breaker. With direct current motors, leads must be protected by a single pole circuit-breaker in each lead, or by an approved double coil, double pole circuit-breaker so designed that each pole must be closed independently of the other.

(b) Circuit-breakers to be calibrated to 400 per cent of normal motor current, and with squirrel-cage motors must also be equipped with time-element relays.

(c) No fuses nor other overload release devices except circuit-breakers are permitted, except in instrument and pilot light leads.

WIRING.—Insulation on all conductors in connection with controller equipment must be of approved type.

SWITCH.—A double throw knife switch for two independent sources of supply must be provided, having one pole for each supply wire in circuit.

PILOT LAMP AND INSTRUMENTS.—(a) A pilot lamp connected on the motor side of the circuit-breakers must be provided to indicate the presence of voltage on the line.

(b) A voltmeter and ammeter must be provided and suitably mounted and connected as a part of the control equipment, and space must be provided on the panel for mounting a watt-hour meter.

MARKING.—(a) A name plate must be provided giving the name of the manufacturer and the rating of the equipment in volts and amperes.

(b) All line and motor terminal connections must be suitably marked so that they can be readily identified.

OPERATING MECHANISM, COMBINED MANUAL AND AUTOMATIC TYPE.—(a) The automatic operation shall be initially actuated by an approved pressure governor acting directly on the winding of a solenoid or other device or devices, which in turn shall close the main contact, and a series of rheostatic switches admitting current to and cutting out starting resistance from the motor circuits.

(b) The period of motor acceleration shall not exceed 10 seconds, when operating automatically, and such acceleration period shall be governed either electrically or by a suction air dash-pot or other mechanical device, but in all cases the governing action must be such that under the most severe conditions the entire starting operation will be positively and reliably completed.

(c) The manual operation shall be obtained from a crank or lever by which, without change of motion, the same main contact and rheostatic switches that are controlled automatically shall be mechanically closed in proper order.

(d) All devices must automatically return to the off position in case of failure of voltage or in case the operator releases the handle in any but the full running position.

(e) The arrangement must be such that when the motor is started and brought to full speed manually its operation cannot be affected by the pressure governor.

PANEL AND CABINET.—(a) Panel must be constructed of a high-class electrical slate or marble, supported by an iron frame, all to be enclosed in a ventilated, splash-proof enclosing cabinet made of sheet iron or steel not less than No. 12 U. S. gauge in thickness.

(b) The cabinet must be provided with hinged doors of the same material as the cabinet both front and rear, and the swinging radius of these doors must not exceed 24 inches.

(c) The supporting frame must be so arranged that the bottom of the panel will be not less than 24 inches above the floor.

(d) The resistance elements may, if desired, be mounted in a well ventilated extension of the enclosing cabinet. Glass bull's eyes must be provided in the doors, one directly in front of each pilot light.

Installation

MANUAL TYPE.—(a) Must be located close to and within sight of the motor. If a pump room used for no other purpose, and containing no other apparatus except the fire pump, its motor and its accessory appliances, is provided, the controlling equipment must be placed in this room.

(b) Must be so protected that it will not be injured by water escaping from pump or connections.

(c) Except where special exception is made by the inspection department having jurisdiction, the controlling equipment must be protected against mechanical injury by one of the following methods:

(d) Grill or lattice partitions so placed as to completely enclose the control panel and starter.

(e) The entire equipment of panel or starter may be enclosed at the sides, front, back and top in a thoroughly substantial, ventilated sheet iron or steel cabinet, not less than No. 12 U. S. metal gauge in thickness, with hinged doors, and so arranged that the bottom of the panel and the starter will be not less than 24 inches above the floor.

(f) Resistance elements may, if desired, be mounted in a well ventilated extension of the enclosing cabinet.

(g) A glass bull's eye must be provided in the door, directly in front of the pilot light.

COMBINED MANUAL AND AUTOMATIC TYPE.—(a) Must be located in the pump room except by special permission of the inspection department having jurisdiction.

(b) A steel compression tank of a capacity satisfactory to the inspection department having jurisdiction will be required as part of the equipment employing automatic controllers.

Test for Acceptance

MANUAL AND COMBINED EQUIPMENTS.—The test shall consist of not less than two nor more than four hours of continuous and successful operation, figuring not less than three complete operations of starter per minute. The cabinet shall be closed at the beginning of the test and remain closed until after the end of the test. The temperature inside at the top of the cabinet in front of the panel must not rise more than 90 degrees Centigrade (162 degrees Fahr.) above the temperature of the room at the end of the test.

GRAVITY AND PRESSURE TANKS*

WOODEN TANKS

1. **Size.**—(a) The standard sizes of wooden tanks for fire protection are from 10,000 to 50,000 gallons capacity, although they are sometimes made larger.

The difference between sizes is usually 5,000 gallons. Tanks of less than 10,000 gallons capacity are not included under these specifications, and if used these specifications should be followed as closely as possible.

When a large quantity of water is to be stored above a building, two or more tanks should be used so that the protection will not be completely cut off when repairing one tank.

(b) The capacity of the tank should represent the volume of water available for fire service and is to be the computed volume between the maximum water level and the outlet level.

2. **Shape.**—Tanks may be either cylindrical or tapered but must be circular in section. If tapered the taper on each side must not exceed ½ inch per foot.

3. **Material.**—(a) White cedar, cypress, white and red pine, Douglas or Washington fir (Oregon pine) or Redwood must be used. Lumber must be free from sap, loose or unsound knots, worm holes and shakes; and be thoroughly air-dried.

Tanks of the best white cedar and those of good cypress are about equally durable, and will last at least fifteen years and commonly twenty or twenty-five years.

Climatic conditions should be considered in selecting the most desirable wood for any location.

4. **Dressing of Lumber.**—(a) Staves and bottom must be made of 2½-inch (dressed both sides to about 2¼-inch) stock, for tanks not exceeding 16 feet diameter or 16 feet deep. For larger tanks, 3-inch (dressed both sides to about 2¾-inch) stock must be used.

(b) All plank must be full length and without splices.

(c) The edges of staves and bottom planks must be jointed on a planing machine and hand jointed with a fore-plane or machine sawn.

(d) The croze (groove for receiving the bottom) must be cut in a true line and at a uniform distance from the bottom of the staves and not deeper than specified in table on page 621. The croze must be cut with due regard for the pitch of the stave when in position and circular in shape so as to be completely filled by tank bottom when staves are well driven up. The lower edge of the bottom must be beveled by planing and the upper edge slightly beveled so as to furnish a smooth surface to fit the croze.

(e) A hole must be bored in both edges of each stave, about 10 inches from the top for ⅝-inch maple dowels or larger, or, small metal dogs must be driven into the top of the staves to hold them in position during erection.

(f) The edges of each bottom plank must be bored with holes not over 3 feet apart for ⅝-inch maple dowels or larger.

5. **Hoops.**—(a) The hoops must be round in cross section.

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* Regulations prescribed by the National Board of Fire Underwriters.

The strength of a tank depends chiefly on its hoops. Experience shows that flat hoops, especially those of steel, rust from the back side where they bear against the staves, and serious accidents have happened by hoops bursting on account of this unobserved corrosion.

(b) The hoops must be made of wrought iron or mild steel of good quality. Wrought iron is preferable, however, because it is more rust-resisting.

The wrought iron must have a tensile strength of at least 50,000 pounds per square inch. Steel must have a tensile strength of 55,000 to 60,000 pounds per square inch.

(c) There must be no welds in the hoops. Where more than one length of iron is necessary, lugs must be used to make the connections, and the several pieces constituting each hoop must be tied together for shipment.

Hoops with "upset" ends are not allowed, because: first, the metal is likely to be burned in upsetting unless done under careful supervision; and second, the additional diameter is likely to be gained by welding bolt ends to smaller rods, thus introducing a weak place at the welds.

When the screw threads are cut directly on the ends of a hoop the unthreaded portion may be corroded to a depth equal to the depth of the threads without weakening the hoop. The screw thread itself is not so liable to serious corrosion as is the portion of the hoop which bears against the staves, since the latter is subjected to moisture from the wood.

(d) The hoops must be bent in the shop so that they will fit closely to the staves all around.

(e) The screw threads on the ends must be made tight fits in the nuts, and they must be U. S. standard as follows:

Diameter of screw ends.......	¾″	⅞″	1″	1⅛″
Number of threads per inch....	10	9	8	7

(f) The hoops must be of such a size and spacing that the stress will not exceed 12,500 pounds per square inch when computed from area at root of thread. Hoops must not be less than ¾-inch diameter.

The following table gives proper working strength for hoops of sizes commonly used based on this allowable stress:

Diameter of Round Rod, Inches	Area of Section of Rod, Square Inches	Net Area at Root of Thread, Square Inches	Safe Working Load, Pounds
¾	.44	.30	3,750
⅞	.60	.42	5,250
1	.79	.55	6,875
1⅛	.99	.69	8,625

(g) The top hoop must be placed within 2 inches of the top of staves. No space between hoops to exceed 21 inches. The hoops must be so placed that lugs will not come in a vertical line. At least three of the staves should be marked before leaving the shop, showing the location of each hoop.

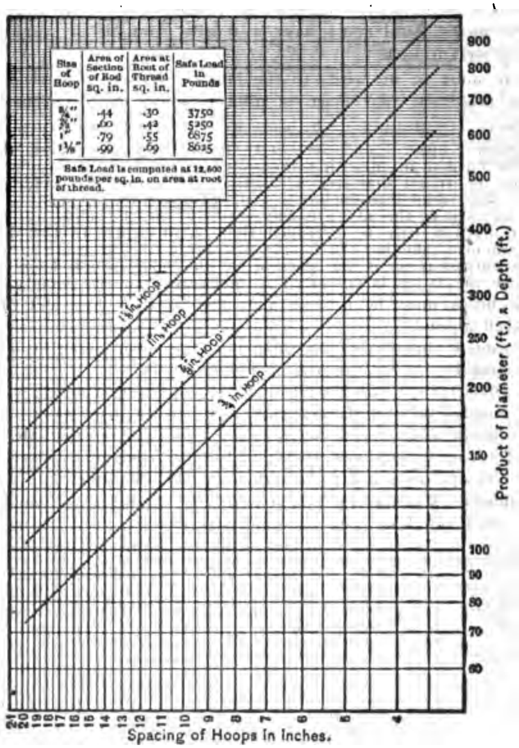
(h) The spacing of hoops may be figured or found from the diagram on page 620.

The depth referred to is the distance from overflow to point where hoop is to be located.

The following example will best show the use of the diagram: How far apart should 1-inch hoops be placed, at 15 feet from the top, on a tank 20 feet diameter?———

15 x 20 = 300. Follow up the right side of the diagram where marked "Product of diameter (feet) x depth (feet)" till you come to 300; then follow the horizontal line to the left till it intersects the diagonal line marked "1-inch Hoop;" then follow downward to the bottom of the diagram, and it will be seen that the hoops under conditions above stated may be spaced 8¾ inches apart.

In a similar way the spacing for any hoop for any size tank may be found.



Size of Hoop	Area of Section of Rod sq. in.	Area at Root of Thread sq. in.	Safe Load in Pounds
¾"	.44	.30	3750
⅞"	.60	.42	5250
1"	.79	.55	6875
1⅛"	.99	.69	8625

Safe Load is computed at 12,500 pounds per sq. in. on area at root of thread.

DIAGRAM SHOWING ALLOWABLE SPACING OF HOOPS

$$\text{Spacing of Hoops in inches} = \frac{\text{Safe Load for given Hoop in lbs.}}{2.6 \times \text{dia. (ft.)} \times \text{depth (ft.)}}$$

(i) Extra hoops must be provided near the bottom to take the additional load due to the swelling of the bottom planks. For tanks up to 20 feet in diameter, one hoop of the size used next above it must be placed around the bottom opposite the croze. For tanks 20 feet or more in diameter two hoops must be used as above.

The hoop or hoops at the croze are to be counted upon as taking the water pressure of half the space above.

(j) The sketches on pages 622 and 623 show the proper spacing of hoops for tanks of standard sizes.

6. **LUGS.**—(a) Malleable iron lugs as strong as the hoop iron must be used. An acceptable form of lug is shown in Figure 95. Lugs of other patterns may be used, however, after first having been approved.

Cast-iron lugs, not malleableized, are not acceptable, as they are liable to crack.

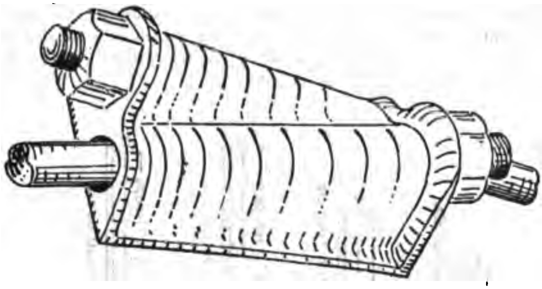


FIG. 95—Lug for Hoops

7. **DIMENSIONS FOR TANKS OF STANDARD SIZES.**—(a) For convenience and illustration the following table giving dimensions for a few tanks of certain sizes is added. The number and size of hoops are stated and the spacing is shown on pages 622 and 623. The proper size and spacing of hoops for tanks of other dimensions can readily be computed by use of the diagram on page 620, as explained under Article 5h.

Approx. Net Capacity	SIZE (Outside Dimensions)		Thickness of Lumber After Being Machined		Extension of Stave below the bottom Inches	Depth of Croze in Stave for bot'm Inches	Width of Croze for bottom Inches	HOOPS	
Gallons	Average Diam., Ft.-In.	Length of Stave Ft.	Staves In.	Bottom In.				No. of	Size In.
10,000	13–4	12	2¼	2¼	3½	⅝	2⅛	11	¾
15,000	14–6	14	2¼	2¼	3½	⅝	2⅛	14	¾
20,000	15–6	16	2¼	2¼	3½	⅝	2⅛	5 11	¾ ⅞
25,000	17–6	16	2¾	2¾	3½	¾	2⅝	4 12	¾ ⅞
30,000	18–0	18	2¾	2¾	3½	¾	2⅝	4 16	¾ ⅞
40,000	19–6	20	2¾	2¾	3½	¾	2⅝	3 10 11	¾ ⅞ 1
50,000	22–0	20	2¾	2¾	3½	¾	2⅝	4 19	⅞ 1

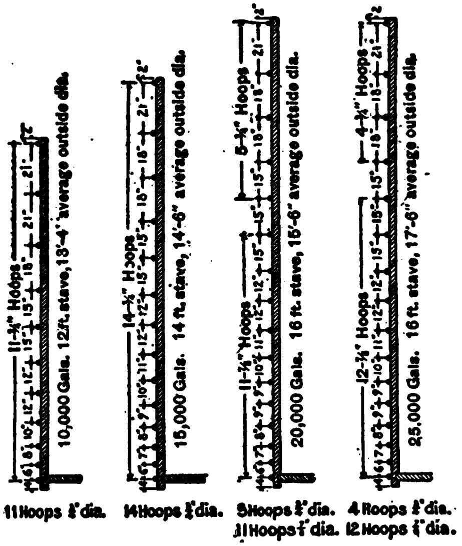
Table Giving Dimensions of Wooden Tanks of Standard Sizes

8. SETTING UP.—(a) The joint between staves should not be permitted to come nearer than ½ inch in line with a joint between the bottom planks.

(b) In setting up the nuts on the hoops, special care should be taken that they are not set up so tight that a heavy initial stress is put on the hoops.

(c) At least one extra stave should be sent with each tank, because an extra piece may be needed to complete the tank on account of shrinkage. The last stave should be fitted into place by jointing off to size required.

(d) The tank must not be exposed to the weather before it is set up and pipe connections should be made promptly after setting up so that the tank may be filled as soon as possible.


11-¾" Hoops
10,000 Gals. 12 ft. stave, 13'-4" average outside dia.
14-¾" Hoops
15,000 Gals. 14 ft. stave, 14'-6" average outside dia.
5-¾" Hoops
11-⅞" Hoops
20,000 Gals. 16 ft. stave, 15'-6" average outside dia.
4-¾" Hoops
12-⅞" Hoops
25,000 Gals. 16 ft. stave, 17'-6" average outside dia.
11 Hoops ¾" dia.
14 Hoops ¾" dia.
5 Hoops ¾" dia.
11 Hoops ⅞" dia.
4 Hoops ¾" dia.
12 Hoops ⅞" dia.

PROPER SPACING OF HOOPS

Allowable working stress 12,500 lbs. per square inch on section at root of thread.

(e) Tanks should be painted on the outside of staves and bottom planks. The hoops should first be painted with red lead, zinc oxide and linseed oil as described in Article 36a.

(f) Tank must be made absolutely water-tight without the use of any caulking or lining material.

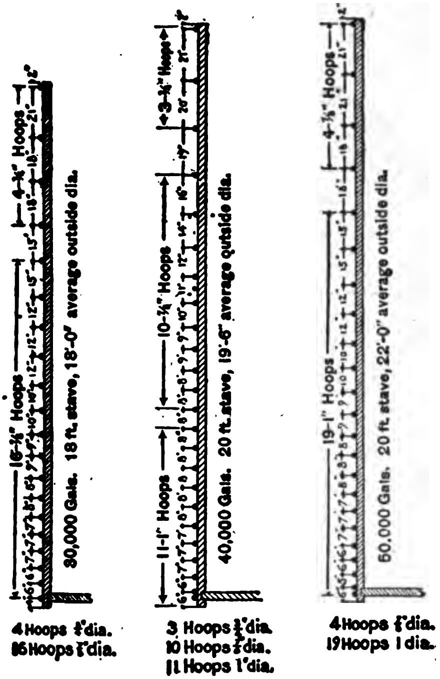
Leaks are due to faulty material or poor workmanship.

9. ROOF.—(a) Tanks located outdoors must be covered with a double roof, an acceptable construction being shown in Figure 96. It must consist of a tight flat cover made of matched boards supported by joists and above this a conical roof. In the larger sizes the conical roof must be supported by rafters extending from the top of the tank to the peak of the roof.

(b) The conical roof must be covered with galvanized sheet iron or a good composition roofing which is not readily ignitible.

(c) The joint between the conical roof and the flat cover must be made tight in order to keep out the wind and maintain a dead air space between the two covers. One method of making a tight joint is shown in Figure 96.

10. HATCHES.—(a) Hatches must be provided in both the conical and flat covers so as to give easy access to the interior of the tank. The hatch covers must be made so they will not bind when swollen from dampness, and the hinges and fastenings must have bearings of non-corrodible metal such as brass. The covers must make a tight joint at the hatch edges, the one in conical roof to have edges turn down over raised edges of hatch.



PROPER SPACING OF HOOPS

Allowable working stress 12,500 lbs. per square inch on section at root of thread.

(b) The hatch cover in the conical roof, when hinged, must be arranged to open to one side (preferably to the right) in order that it may be reached in all positions by a man on the ladder. When cover is arranged to slide it must move upwards to open.

The hatch cover in flat cover may be set loosely in place without hinges or guides, and be furnished with a handle so that it can be readily lifted off and set to one side.

Hatch to be located preferably on southern side of tank and must not be less than 20 inches by 26 inches, inside measure, in size.

11. Supports.—(a) The weight of the tank must be supported entirely from its bottom; and in no event should any weight come on bottom of staves.

(b) There must be a clear space of at least 1 inch between bottom or outside of staves and balcony when used.

12. Discharge Pipe.—(a) The discharge pipe must be made up of cast-iron or wrought pipe, flanged or coupled. Copper gaskets must be used between flanges.

(b) Size of discharge pipe to be specified by inspection department having jurisdiction.

The size of discharge pipe should not ordinarily be less than 6 inches. In small equipments with a short run of pipe a 4-inch or 5-inch pipe may be used. For sizes 20,000 to 75,000 gallons inclusive an 8-inch pipe is suggested, and for sizes over 75,000 gallons a 10-inch pipe.

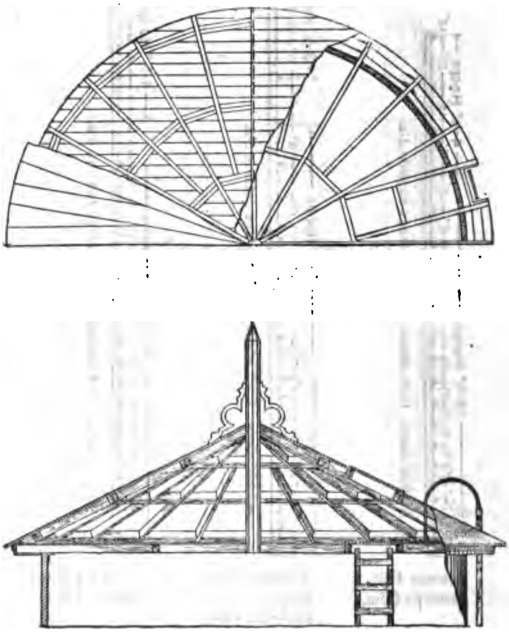


Fig. 96—Arrangement of Double Cover

(c) The pipe should preferably leave the tank bottom at its center.

(d) When the pipe drops vertically to the ground level the pipe must be supported on an underground elbow having a foot piece resting on a concrete foundation, and the elbow should preferably be flange-connected to the underground pipe. If bell and spigot connection is used the joint should be strapped.

(e) Except where tank is the only supply to the system, an approved check valve must be placed in the tank discharge pipe, underground where feasible, and as far from the tank as practicable.

Note.—For tanks on detached trestles, check valve may be near the footing elbow. It is desirable to enclose the check valve in an approved pit so as to be readily accessible for inspection and repairs.

(f) Tank discharge must be controlled by two approved gate valves, one on each side of the check valve. Where tank discharge pipe runs through a building, the gate valve in the tank side of the check must be located in the building near where tank pipe enters. With tanks on detached trestles where discharge pipe enters the ground the gate valves may be either outside-screw-and-yoke or other approved indicator valves in pit with check, or, of the post indicator valve type.

With small tanks on trestles the valve nearest the tank may be omitted with the permission of the inspection department having jurisdiction.

The pipe and valves must be installed promptly so that the tank may be filled as soon as possible after erection to avoid drying and warping of the staves.

(g) The pipe must be braced laterally at girt connections to the tower and not over 40 feet apart. Four adjustable diagonal rods not less than ⅝-inch diameter to be used. Where standard boxing is used, the rods may be attached to boxing or to pipe.

13. FILLING PIPE.—(a) Filling pipe must be at least 1½ inches diameter.

(b) When tank is exposed to the weather, the pipe must be carried up inside the frost-proof casing, and extend through tank bottom to discharge at top of tank above water level. The portion of pipe inside tank must be brass. The pipe may be run up outside of tanks located inside buildings.

(c) Large tanks, particularly those located at some distance from the source of supply, may be filled through a by-pass, around check valve. Size to be 2 inches for discharge pipe of 6 inches or less in diameter, 3 inches for 8-inch discharge and 4 inches for 10-inch discharge or larger. An approved globe, outside-screw-and-yoke or post indicator valve, ordinarily kept closed, to be provided in the by-pass.

14. DRAIN.—(a) An approved 2-inch outside-screw-and-yoke gate or globe valve must be provided on nipple connected to discharge pipe above valves to drain tank and riser.

(b) A suitable outlet must be placed in tank bottom to drain the settling basin.

15. EXPANSION JOINT.—(a) When a tank is supported by a structure 30 feet or more in height, whether on the ground or on a building, an expansion joint of the type shown in Figure 97 must be provided in the discharge pipe at the tank connection.

In cases where a tank is located in a heated enclosed tower, a four-elbow swing joint may be used.

(b) The tank connection may be made by threading a half coupling over the stuffing box and bearing against an annular washer, as shown in Figure 3, or by bolts passing through the tank bottom.

(c) The gland must be of brass and a brass ring must be provided at bottom of packing space so that sliding contact will be between brass and iron surfaces.

Expansion joints having iron to iron sliding contact have given trouble in service because of breakage of fittings and loss of water from tank due to rusting and sticking together of the parts.

(d) The gland bolt nuts must be of brass.

(e) A minimum clearance of ½ inch must be provided between the riser pipe and the cast-iron stuffing box.

(f) The stuffing box casting must be extended to project 4 inches within the tank to insure a minimum capacity for a settling basin to prevent sediment depositing in the pipe system and to keep the packing free from sediment. The riser pipe must also be fitted so that the upper end is about 5 inches below top of expansion joint.

NOTE.—The extension piece is installed to insure a settling basin of the desired depth even if the discharge pipe should be cut somewhat shorter than intended.

(g) A large packing space, 1 inch wide by 5 inches deep, must be provided so as to make it unnecessary to repack the joint except at long intervals.

(h) A good packing, such as asbestos wicking soaked with rape oil and graphite, must be provided in stuffing box.

16. OVERFLOW.—(a) The overflow pipe must be 2 inches in diameter for tanks up to 30,000 gallons capacity and 3 inches in diameter for larger tanks.

A short length of 2-inch pipe will discharge about 100 gallons per minute when the surface of the water is three inches above the center of the pipe.

(b) The top of the overflow pipe must be placed 3 inches below the top of the staves.

(c) The overflow pipe must extend through the bottom or side of tank. In the latter case it must project beyond the balcony.

(d) The overflow pipe should not be brought out through the riser boxing. This arrangement has caused trouble on account of freezing.

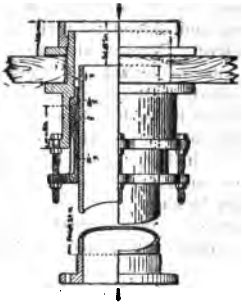


FIG. 97—Expansion Joint for Wooden Tanks

17. HEATING.—(a) Arrangements must be made to warm the water in tanks where subject to freezing. The temperature of the water should not be allowed to go below 40 degrees F. or above 160 degrees F.

NOTE.—When the tank is in an enclosure such as a mill tower, the heating system of the mill may be used to heat the tower so that no further heating apparatus will be needed.

The following heating methods are acceptable:

1. Circulation of Warm Water. The heater to consist of coils of pipe, preferably of brass, enclosed by a water jacket. The discharge pipe from heater must be enclosed in the frost-proof boxing or other covering of tank drop and terminate in an open tee at about the middle of tank. Discharge pipe at no point to be lower than the heater; must be provided with expansion joint or four elbows, and must be properly braced near its top inside of tank. There should be a properly designed relief valve on this pipe between the heater and discharge valve.

The return pipe to heater must be connected to tank drop on the tank side of tank check and must be without pockets. Heater must be so located that there will be circulation of water in all of the pipe exposed to frost, and always be located at or near the base of tank drop and below frost line when tank drop is exposed for its full length and enters the ground.

When the tank is on a tower. which is close to a building or above it, the heater may be placed within the building.

The heater may be operated by either: (a) Steam, if constant and of sufficient pressure, and preferably by a direct pipe from boiler. A steam trap must be provided at heater for condensed steam, with a high pressure boiler (10 pounds or over); (b) Hot water if constant and of proper temperature; (c) A small coal or gas heater of ample strength to resist tank pressure. Heating capacity ample for size of tank must be provided, and if necessary two or more heaters should be installed. If heater is in a pit under tank tower, pit must be of ample size to allow ready access for inspection and maintenance. If coal or gas is used for heat, the heater must be installed in a fire-resistive enclosure. A thermometer must be located in the return pipe at or near the heater to give the temperature of the water. Where the discharge and return pipes of the heater are run inside of a building, it is advisable to provide gate valves on these as close to where they leave the building as possible, so as to save water damage in the building in case of a break in the pipes.

2. Steam Coil. A steam coil of brass pipe may be placed in tank securely fastened 6 inches above the bottom. This must be supplied by a steam pipe of ample size running direct from boiler below frost line up through the frost-proof boxing. Return pipe should be run along side of the feed pipe. Condensed steam must be properly cared for by a trap.

3. Steam Jet. This may be used, where conditions warrant, with the permission of the Underwriters having jurisdiction. A steam pipe at least 1 inch in diameter should be run direct from boilers, below frost line where necessary, and up through the frost-proof boxing of the tank discharge through bottom of tank. It should extend to a point above the surface of the water and then turn down at least 3 feet. A vent must be provided at upper level of pipe to prevent siphoning back.

18. **FROST-PROOFING FOR PIPES.**—(a) The discharge and hot water or steam pipes, and separate filling pipe when one is needed, for a tank on a tower on the ground or roof of a building, must be protected from freezing by a frost-proof covering in addition to having the water in the discharge pipe heated.

The frost-proof covering should not be depended upon to prevent freezing of the pipes without some heat being added. Most tanks for fire protective purposes have no draft from them except in case of fire, therefore the water in the discharge pipes has little or no circulation. For this reason, these pipes need more thorough protection than do pipes in similar positions which discharge from tanks in which there is nearly constant circulation, as for example in a village supply. Therefore the amount of protection to be provided for a certain pipe must be decided with due regard to the severity of exposure to cold winter winds, frequency of circulation in the pipe and amount of heat to be supplied.

The standard frost-proof boxings are made of wood and are circular or square in section as shown in Figures 98 and 99 respectively.

The boxings may be made more durable by using stock which has been antiseptically treated.

(b) A good tight joint must be made between boxing and bottom of tank. The lower end of boxing must be supported by the sides of the pit, which must extend about a foot above ground. The woodwork must be well painted. Sheet lead or tarred paper should be placed between bottom of boxing and the pit to avoid absorption of moisture.

(c) The upper part of boxing must be constructed so as to permit of access to the expansion joint without the necessity of destroying any portion of the boxing.

(d) The boxing must be made four-ply, with two air spaces, for tanks in Northern Canada. It must be three-ply, with two air spaces, as shown in Figures 98 and 99 for tanks in New England, New York, Southern Ontario, Michigan and Wisconsin. Two-ply boxing with two air spaces must be used in states immediately south of this section. This boxing may also be used in the Southern States or else the pipes may be wrapped with felt and tar paper and covered with canvas well painted.

19. GAUGE.—(a) An approved form of telltale for showing the height of water in the tank must be provided.

(b) The following telltales are aceptable:

1. Approved Sprinkler Supervisory Device. (Signaling Rules.)

2. Mercury Gauge.

(a) As this gauge is connected to the yard pipe it is a separate fitting which is not furnished by the tank builders unless definitely included in their contract. The gauge will usually be furnished by the sprinkler contractor who installs the riser pipe, although it may be installed by the owner if desired. Mercury should be filtered.

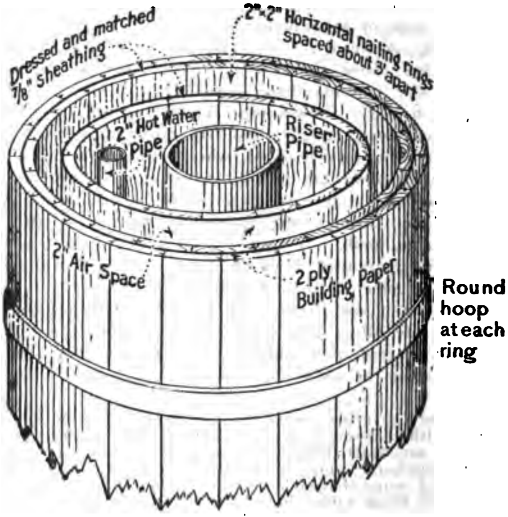

Dressed and matched 7/8" sheathing
2"-2" Horizontal nailing rings spaced about 3' apart
2" Hot Water Pipe
Riser Pipe
2" Air Space
2 ply Building Paper
Round hoop at each ring

FIG. 98—Circular Frost-Proof Boxing

(b) An approved design of gauge is shown in Figure 100.

(c) The gauge must be installed in a convenient, warm, inside location so that the graduated board will be in plain sight for reading, and the mercury pot easily accessible for maintenance.

As a first rough approximation, the distance of the center of the mercury pot below the center of the gauge board may be taken as 7½ per cent of the height of the top of the tank above the board.

When a location thus chosen proves satisfactory, set up apparatus as shown in Figure 6, placing the board more exactly by locating the top of the scale "A" a distance in feet above "B" equal to 17 per cent of the pressure at "B" in pounds per square inch (or 7.4 per cent of height in feet of the water level above "B"), when the tank is full.

Connect pipe "C" to the tank riser on the tank side of the check valve, burying all underground pipe well below frost and protecting other pipe where exposed to frost.

Locate air and test cock "D" at a convenient point for testing with gauge board in plain sight. Remove plug "E" and with valve "F" closed, fill the mercury pot with mercury through opening at "E" until the glass window "G" is covered, then fill to overflowing with water and insert plug "E." Open valve "F" and cock "D" until water flows freely, then close cock "D." Finally with the tank filled to level of the overflow, adjust gauge board so that the "full" mark comes opposite the mercury level in the glass tube, and then secure the board firmly in place.

(d) The gauge should be tested occasionally to insure that it is in proper operative condition as follows:

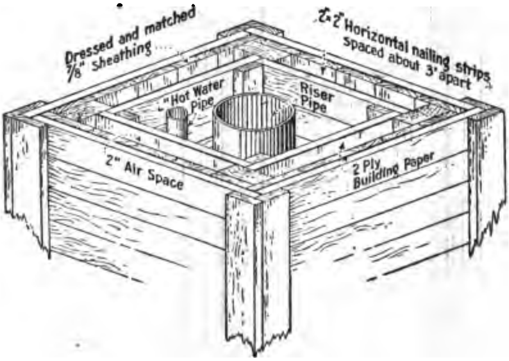


FIG. 99—Square Frost-Proof Boxing

1st, Open cock "D." This should cause mercury level to lower. Close "D" and note if mercury level rises to former point. If it does not, then valve "F" is probably closed or pipe "C" is plugged.

2nd, Note if mercury can be seen through glass window "G." If not, close valve "F" and fill mercury pot as directed above.

Be sure to leave valve "F" open and sealed.

3. Float telltales.

Float telltale to consist of a float of ample size and buoyancy, such as a tight cask, connected to a non-corrosive chain or flexible cable of ample strength. This should run over suitable non-corrosive pulleys and must be boxed where exposed to weather. Chain should run down through a pipe of not less than ½-inch diameter and register on a dial located either at foot of trestle or in first story of building. Dial must be marked off in feet; must be solid on back and sides and be protected by netting or glass on front.

Where upper part of tank is used for factory service or where there is a reliable ball float with constant water pressure in filling pipe, the telltale may be omitted by permission of the inspection department having jurisdiction.

20. LADDERS.—(a) A steel ladder must be provided on the outside of the tank, extending to the top, so as to afford easy access to the hatch in the tank roof.

(b) The ladder must be constructed with not less than 2 x ⅝-inch flat side bars, spaced not less than 14 inches apart, and not less than ¾-inch round or ⅝-inch square rungs, spaced not more than 12 inches apart. The rungs must be riveted through slotted holes in the side bars to prevent their turning. The square rungs must be placed corner up.

(c) Ladder must be secured to steel grillage or balcony supports by flat bar brackets in such a way as to properly support the weight of the ladder and 1,000 pounds in addition. Ladder must be at least 6 inches from side of tank.

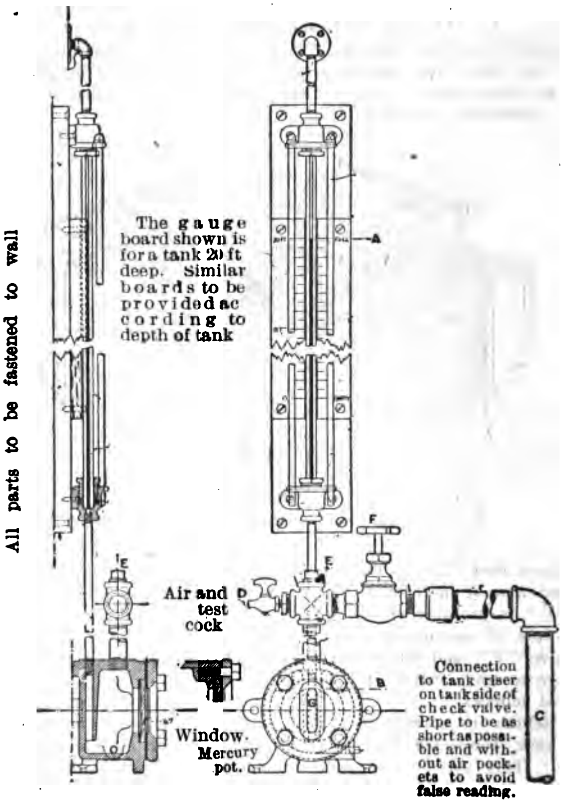

All parts to be fastened to wall
The gauge board shown is for a tank 20 ft deep. Similar boards to be provided according to depth of tank
A
F
E
E
D
Air and test cock
B
G
C
Window.
Mercury pot.
Connection to tank riser on tank side of check valve. Pipe to be as short as possible and without air pockets to avoid false reading.

FIG. 100—Mercury Gauge

(d) The ladder must extend about 18 inches above the side of tank, then arch downward to the cover to form a handrail, as shown in Figure 96, so that a man standing near its top can readily reach up and open with his right hand the hatch cover in tank roof. The handrail should be made of not less than ⅝-inch round rod.

(e) A substantial wooden ladder must be provided inside of the tank extending from the trap door to bottom of tank. Must be made of at least 2-inch by 4-inch side pieces and 1-inch by 2-inch cleats securely set in and spiked to the side pieces.

21. **Lightning Rods.**—Wooden or concrete tanks in locations subject to thunder storms must be equipped with lightning rods. These must be installed according to the rules of the National Board of Fire Underwriters.

STEEL TANKS ON TRESTLES

22. **Size.**—(a) The usual sizes of steel tanks for fire protection are from 20,000 to 150,000 gallons capacity although they are sometimes made larger.

When a large quantity of water is to be stored above the building, two or more tanks should be used so that the protection will not be entirely cut off when repairing one tank.

(b) The capacity of the tank should represent the volume of water which is available for fire service and is to be the computed volume between the maximum water level and the outlet level.

CAPACITIES OF CYLINDERS AND TANK BOTTOMS
U. S. GALLONS

Diameter in Feet	Gallons per Vertical Feet of Cylinder	Gallons in Hemispherical Bottom	Diameter in Feet	Gallons per Vertical Feet of Cylinder	Gallons in Hemispherical Bottom
10	587.5	1,958	31	5,646	58,342
11	711	2,607	32	6,016	64,170
12	846	3,385	33	6,398	70,378
13	993	4,303	34	6,792	76,976
14	1,152	5,374	35	7,197	83,965
15	1,322	6,610	36	7,614	91,368
16	1,504	8,022	37	8,043	99,197
17	1,698	9,621	38	8,484	107,464
18	1,904	11,422	39	8,936	116,168
19	2,121	13,432	40	9,400	125,333
20	2,350	15,667	41	9,876	134,972
21	2,591	18,137	42	10,364	145,096
22	2,844	20,853	43	10,863	155,703
23	3,108	23,828	44	11,374	166,819
24	3,384	27,073	45	11,897	178,455
25	3,672	30,600	46	12,432	190,624
26	3,972	34,421	47	12,978	203,322
27	4,283	38,547	48	13,536	216,576
28	4,606	42,991	49	14,106	230,398
29	4,941	47,763	50	14,688	244,800
30	5,288	52,877			

23. **Form.**—(a) Tanks must be cylindrical with hemispherical or elliptical bottoms, except where conditions do not permit a curved bottom, in which case a flat bottom may be used.

24. **Plates.**—(a) The steel for tank plates must be made by the open hearth process. The cylindrical plates must have an ultimate strength of from 55,000 to 65,000 pounds per square inch, and the bottom plates, 45,000 to 55,000 pounds per square inch. The steel must withstand a cold bending test of 180 degrees flat upon itself to a diameter not greater than thickness of plate without fracture of the outside bent surface.

(b) The thickness of the plates for the tank and balcony must be not less than ¼ inch. For 60,000-gallon tanks and larger the plates of the lowest cylindrical ring must be not less than 5/16 inch thick, and for tanks 75,000 gallons and larger the bottom plates must be not less than 5/16 inch thick. Flat bottom plates must be made ⅛ inch thicker than the lowest cylindrical ring in all sizes.

The thickness of the roof plates must be not less than ⅛ inch.

(c) The rings of plates of the cylindrical portion must be placed with the lower edges outside the upper edges at the lap joints.

(d) The joint between the cylindrical portion and the bottom must be made by lapping the lowest ring over the plates of the bottom on the outside.

(e) The joints for the seams of the bottom cylindrical plates must be lapped.

(f) The plates must all be formed cold.

25. RIVETS.—(a) The steel for rivets must be made by the open hearth process. It must have an ultimate strength of from 48,000 to 58,000 pounds per square inch, an elastic limit not less than one half the ultimate strength, and an elongation of 26 per cent.

(b) The shearing stress on rivets must not exceed 7,500 pounds and bearing stress 15,000 pounds per square inch.

(c) Rivets must have full heads concentric with rivet of a height not less than 6/10 the diameter on outside of tank, but low cone heads are acceptable for inside.

(d) Rivets when driven must completely fill the holes and be in full contact with surface, or be countersunk when so required.

26. RIVET HOLES.—(a) Plates ¼ inch to ⅝ inch in thickness may be punched. The diameter of the punch must not exceed the diameter of the rivet by more than 1/16 inch.

(b) Plates ⅝ inch to ⅞ inch in thickness must be subpunched with a punch 1/16 inch smaller in diameter than the nominal size of the rivets and must be reamed to a finished diameter not more than 1/16 inch larger than rivet.

(c) Plates thicker than ⅞ inch must be drilled to a diameter not more than 1/16 inch larger than rivet.

27. RIVETING.—(a) All rivets must be entered from the outside of the tank and driven from the inside.

(b) The joints of the tank plates must be riveted, so that the unit stresses on the net section of the plates and rivets will not exceed those specified.

(c) The spacing between rivets along the caulked edges of plates, except at column connections, must not be greater than ten times the thickness of plates. The spacing along the edges of plates which are not caulked must not exceed 6 inches nor 16 times the thickness of the thinnest outside plate.

28. ASSEMBLING.—(a) Drift pins must be used only for bringing the parts together and must not be driven with such force as to disturb the metal around the rivet hole.

(b) The tank must be made absolutely water-tight by caulking along the edges from the inside of the tank with a round nosed tool. Caulking must be done before painting.

Foreign material such as lead, copper filings, cement, etc., must not be used in the joints between the plates.

29. CIRCULAR GIRDER.—(a) When the posts have a batter, it is necessary to oppose the inward thrust exerted by them on the tank by a circular girder placed in such a position with regard to the connection that the bending moment produced in the posts is a minimum.

The use of structural steel members within the tank in place of the circular girder is not acceptable.

(b) The girder must be not less than 24 inches in width except when posts are vertical, when it may be reduced to 18 inches, and must have a web plate not less than ¼ inch thick. It must be stiffened at the edges by flange angles, channels or other structural shapes. It must be designed to support a 1,000-pound concentrated load applied vertically at any point.

(c) When it is necessary to cut into the web of the girder at the post connections to the tank, the depth of the cut must be kept a minimum and the opening must be thoroughly reinforced.

(d) Where splices are made in the girders, there must be sufficient strength at these points to carry the load of the inward thrust.

(e) Holes must be punched in the web of the girder to allow drainage.

30. BALCONY.—(a) A balcony must be provided on all tanks on towers 30 feet or higher. The circular girder will serve as a balcony for steel tanks.

(b) A railing about 3 feet high must be provided around the balcony. It should be built of angle irons and well stiffened sidewise.

(c) Drain holes must be provided in the balcony floor when design is such that it does not allow water to run over edge.

31. CONNECTION OF POSTS TO TANK.—(a) In order to avoid eccentric loading in the posts and local stresses in the tank plates, the connection between the posts and the tank must be made in such a manner that the center of gravity of the column section shall intersect the tank at the center of the girder connection. An acceptable design is shown in Figure 101. Other designs are also acceptable, but these should be approved by the inspection department having jurisdiction.

32. EXPANSION JOINT.—(a) When a tank is supported by a structure 30 feet or more in height, whether on the ground or on a building, an expansion joint of the type shown in Figure 102 must be provided in the discharge pipe at the tank connection.

In cases where a tank is located in a heated enclosed tower, a four-elbow swing joint may be used.

(b) The expansion joint may be connected to tank by rivets, as shown in Figure 102, or by bolts with lead gaskets and steel washers.

(c) The gland must be of brass and a brass ring must be provided at bottom of packing space so that sliding contact will be between brass and iron surfaces.

Expansion joints having iron to iron sliding contact have given trouble in service because of breakage of fittings and a loss of water from tank due to rusting and sticking together of the parts.

(d) The gland bolt nuts must be of brass.

(e) A minimum clearance of ½ inch must be provided between the riser pipe and the cast-iron stuffing box.

(f) The stuffing box casting must be extended to project 18 inches within the tank to insure a minimum capacity for a settling basin to prevent sediment depositing in the pipe system, and to keep the packing free from sediment. A wrought iron pipe may be threaded into the casting to form an extension piece if desired. The riser pipe must also be fitted so that the upper end is about 12 inches below top of expansion joint.

See note under 15f.

(g) A large packing space, 1 inch wide by 5 inches deep, must be provided so as to make it unnecessary to repack the joint except at long intervals.

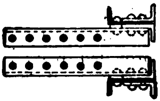
(h) A good packing, such as asbestos wicking soaked in rape oil and graphite, must be provided in stuffing box.

33. ROOF.—(a) A sheet metal roof, not less than ⅛-inch thick and conical in shape, must be provided on tanks located outdoors. The joints of the plates must be lapped and riveted. The joints between the roof and the top of the tank must be made tight in order to keep out the wind and maintain a closed air space above the surface of the water.

The appearance of the tank is improved by having the roof project beyond the tank the same distance as the balcony.

(b) A finial made of cast iron, zinc or galvanized sheet iron must be tightly fitted to apex of roof.

34. HATCHES.—(a) A hatch not less than 20 inches by 26 inches, inside measure, must be provided in the roof (on south side when feasible), so as to give easy access to the interior of the tank. The hinges and fastenings must be made of some non-corrodible metal, such as brass, or have non-corrodible hinge pins and bearings. The cover must make a tight joint and its edges must turn down over raised edges of hatch.



Section at Balcony.

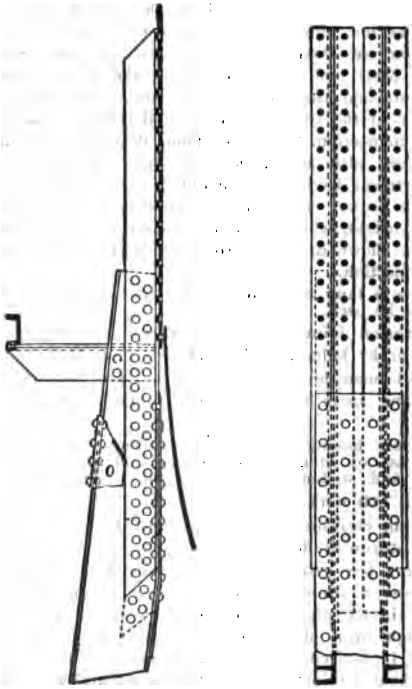


FIG. 101—Post Connection to Tank

(b) The hatch cover, when hinged, must be arranged to open to one side (preferably to the right), in order that it may be reached in all positions by a man on the ladder. When cover is arranged to slide, it must move upwards to open.

35. **PAINTER'S TROLLEY.**—(a) Some reliable form of trolley or other acceptable device must be provided to facilitate repainting of the tank.

36. **PAINTING.**—(a) The plates must be given a priming coat at the shop. The surface of the metal must be thoroughly cleaned of mill scale, rust and grease and the surface must be perfectly dry before applying the paint.

A good paint for the first coat may be made by mixing 20 pounds of red lead and 10 pounds of zinc oxide with about 3 quarts of boiled linseed oil, the red lead and zinc oxide being ground in. This will cover about 50 square yards of surface.

(b) A second coat must be applied after the tank is erected. For this coat a more durable oil or asphaltum paint must be used.

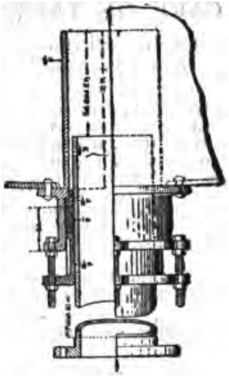


FIG. 102—Expansion Joint for Steel Tanks

37. **TYPICAL DIMENSIONS FOR TANKS OF STANDARD SIZES.**—(a) The following table gives the typical dimensions of cylindrical, hemispherical bottomed tanks of standard sizes. Other dimensions which provide the full net capacities are equally acceptable.

CAPACITY—GALLONS			SIZE—FEET AND INCHES	
Rated or Approximate Net	Actual Net	Total	Diameter	Height
30,000	30,036	30,516	15–0	18–1
40,000	40,045	40,610	17–0	18–3
50,000	50,004	50,613	18–0	20–7
60,000	60,148	60,800	19–0	22–4
75,000	75,089	75,788	20–0	25–7
100,000	100,166	100,959	22–0	28–2
150,000	150,223	151,164	25–0	32–10

The height given is that of the cylindrical portion. The method of calculating the net capacity is explained in Article 21b.

38. **GENERAL FEATURES.**—(a) The requirements for discharge and filling pipes, overflow, drain, heating and frost-proofing, mercury gauge and ladders are given in section on wooden tanks, except as follows:

(b) The ladder must be securely fastened by flat bar brackets of sufficient strength to carry the weight of the ladder and 1,000 pounds additional. The ladder must extend about 18 inches above the side of tank, then arch downward to the cover to form a handrail, as shown in Figure 2, so that a man standing near its top can readily reach up and open with his right hand the hatch cover in tank roof. The handrail should be made of not less than ⅝-inch round rod. A steel ladder of the same construction as for outside ladders must be provided inside tank. The ladder must extend down to within easy reach of the expansion joint.

(c) Top of overflow pipe to take out one inch from top of tank.

CARE OF TANKS

39. **General.**—(a) Tanks for fire protection should not be used for other purposes except with the permission of the inspection department having jurisdiction.

The practice of using a foot or so of water for mill purposes from the top of a tank is objectionable; because when so used the tank collects a larger amount of sediment from the water which is constantly being supplied than it does when used for fire service only. This sediment is likely to settle in the sprinkler pipes, and either to clog them completely, or, in case sprinklers open, to seriously interfere with their discharge. If water is drawn from the bottom for mill purposes, the tank may, of course, be empty when needed for the fire service. Furthermore the fluctuation of water level is liable to result in shrinkage of the upper ends of the staves, and leakage.

Where water is clean and without sediment, part of the tank may be used for domestic purposes with permission of the inspection department having jurisdiction.

(b) Tanks should be thoroughly examined at least twice a year to see that they are in good order.

(c) The sediment which collects in the tank bottom should be cleaned out when it reaches the top of the expansion joint casting.

(d) Examine flat hoops on old tanks very carefully to see if they are rusting from the back. If they are found to be corroded so as to materially weaken them, the tank should be strengthened by placing new hoops of round iron between the flat hoops, or by replacing the flat ones with round hoops of proper size and spacing.

A flat hoop may be in perfect condition at one point and nearly rusted off within six inches of that point. Flat hoops rust more rapidly where they do not fit tightly against the staves, because dirt collects there and holds the dampness. In making an examination of flat hoops place a round hoop on each side of one of the lower flat ones, within easy reach, then strike this flat hoop with a pointed hammer at intervals of a few inches to detect thin places.

Particular attention should be given to tanks located on roofs and covered with corrugated iron as, unfortunately, some building laws require. The hoops corrode very rapidly on account of the dampness held between the corrugated iron and the staves, and they may be found nearly rusted off in a few years after erection.

(e) The inside and outside of the tank should be repainted frequently or when the paint shows signs of peeling. The surface must first be carefully cleaned by a sand blast or by steel brushes and scrapers. The metal must be thoroughly dried before the paint is applied.

SPECIFICATIONS FOR STEEL TOWERS

These specifications are intended to produce steel towers which are strong and reliable and involve no features which necessitate radical changes in present shop practice or equipments. The towers must, in addition to conforming to the specifications, be satisfactory in the composition of materials, construction of the parts and workmanship.

40. HEIGHT.—(a) The height of the tower shall be the vertical distance from the top of the capstones of the foundations to the outlet level within the tank.

41. FORM.—(a) Towers for supporting tanks of sizes up to and including 150,000 gallons capacity should preferably have four posts. In those few cases where larger tanks are used, the towers may have six posts. Short towers for tanks on buildings may have three posts.

Four-posted trestles are considered preferable to those of more posts, for the reason that the members are larger and less liable to be impaired by corrosion and also more likely to carry the proportion of the load for which they are designed.

In designing a tank trestle, there should be as few angles, corners and places which are difficult to paint, as possible.

42. BATTER OF POSTS.—(a) The post panels must have a batter of not less than 1 to 12, except where conditions do not permit.

43. MATERIAL.—(a) The steel for the structural members must be made of medium grade of from 55,000 to 65,000 pounds ultimate strength and an elastic limit of not less than one half of the ultimate strength. Before or after heating to a low cherry red and cooling in water to 82 degrees F., the steel must stand bending to a curve whose inner radius is 1½ times the thickness of the sample without cracking.

(b) The thickness of the metal of structural members carrying load must be not less than ¼ inch except in the case of channels. This specification does not apply to auxiliary fittings such as fillers, railing, balcony brackets on grillage, etc.

44. RIVETS.—Rivets must have full heads concentric with rivet of a height not less than 6/10 the diameter.

See also Section 25a and d, and Section 57.

45. RIVETING.—(a) All connections must be riveted except those of the wind rods when made adjustable, and the balcony railing.

See also 48 *b*.

(b) The minimum distance between centers of rivet holes must be three diameters of the rivets, but the distance shall preferably be not less than 3 inches for ⅞-inch, 2½ inches for ¾-inch and 2 inches for ⅝-inch rivets.

(c) The maximum distance between centers of rivet holes must never exceed 6 inches.

(d) The maximum pitch in the line of stress for members composed of plates and shapes must be 6 inches for ⅞-inch, 5 inches for ¾-inch, and 4 inches for ⅝-inch rivets, and must not exceed twice this amount where there are two or more gauge lines.

(e) The minimum distance from the center of any rivet hole to sheared edge must be 1½ inches for ⅞-inch, 1¼ inches for ¾-inch, 1 inch for ⅝-inch rivets, and to a rolled edge 1¼ inches, 1⅛ inches and ⅞ inch, respectively.

(f) The maximum distance from edge must be eight times the thickness of the plate, but must not exceed 6 inches.

(g) The diameter of rivets in any angle carrying calculated stress must not exceed ¼ the width of the leg in which they are driven. In minor parts ⅞-inch rivets may be used in 3-inch angles, ¾-inch in 2½-inch angles and ⅝-inch rivets in 2-inch angles.

(h) The pitch of rivets at the ends of built-up compression members must not exceed four diameters of the rivets for a length equal to 1½ times the maximum width of the member.

(i) Hand-driven rivets must not be larger than ⅞-inch diameter.

46. COMPRESSION MEMBERS.—(a) The metal in compression members must be concentrated as much as possible in webs and flanges, and the numbers must be of approved types.

(b) Cover plates must have a thickness not less than 1/40 of the distance between rivet lines. When cover plates are used, only one should be provided on each post.

The posts should be constructed so that all parts are accessible for painting, for which reason the use of two cover plates is not allowable.

(c) Post members built up of two angles placed star-shape, must have pairs of tie plates or tie angles, spaced so that the distance between pairs will not exceed the following:—

Size of post angle	4"	5"	6"	8"
Spacing of ties	24"	36"	42"	48"

There must be at least two rivets connecting each tie to each angle, the number to be increased with increase in size of post angle.

(d) Struts must be connected to columns through gusset plates and in such a manner that the columns are rigidly supported.

(e) Abutting joints in compression members must be faced for bearing so that the surfaces will be finished as smoothly as by milling.

(f) The joints must be spliced on four sides to carry the maximum tension, or half the maximum compression, in the posts, the design requiring the most rivets to be used. There must not be less than two rows of rivets on each side of the joint where size of post member permits. Joints with abutting faces not finished equal to milling must be fully spliced so that rivets will transmit the compression load.

(g) Joints must be placed as near panel points as possible and never more than 18 inches above.

(h) Where foundations are set in soft clay or comparatively loose earth a lower chord should be provided.

47. LATTICE.—(a) The size of rivets for latticing channel flanges of various widths must be as follows: ⅝-inch rivets for flanges less than 2¼ inches wide, ¾-inch rivets for flanges 2¼ inches to 3½ inches wide and ⅞-inch rivets for flanges 3½ inches and wider.

(b) The minimum width of lattice bars for compression members built up of channels must conform to the size of rivets used as follows: 2½ inches for ⅞-inch, 2¼ inches for ¾-inch, 2 inches for ⅝-inch rivets.

(c) The thickness of lattice bars must be not less than 1/40 the distance between end rivets for single lattice and 1/60 for double lattice.

(d) The inclination of lattice bars with the axis of the member must be not less than 45 degrees.

(e) When the distance between rivet lines in the flanges is more than 15 inches, if single riveted bar is used, the lattice must be doubled and riveted at the intersection.

48. GRILLAGE.—(a) For towers to support wooden tanks, a grillage of steel I beams must be provided. These are to be supported by and bolted to post cap I beams which must be braced by steel work or be strapped to the cap beams to prevent overturning. An acceptable form of construction is shown in Figure 103.

(b) When struts are not provided at top of posts below the post cap beams, the latter must be riveted to the cap plates. When struts are provided, the beams may be bolted to the plates.

(c) The grillage beams must be spaced so as to properly support the tank bottom and not to exceed 18 inches in the clear between flanges.

(d) A balcony should be installed on every tank.

(e) The balcony supports must consist of steel members riveted to the grillage beams. They must carry a 1,000-pound concentrated load applied vertically at any point. An acceptable form of support is shown in Figure 103.

49. CAP AND BASE PLATES.—(a) The cap and base plates must be made of steel.

(b) The base plates must be of sufficient thickness, size and properly stiffened so that the masonry shall be loaded uniformly and not overstressed. An acceptable design of base plate for angle iron posts is shown in Figure 104. and for channel posts in Figure 105. Other designs which are equally good are also acceptable but should be approved by the inspection department having jurisdiction.

50. ANCHOR BOLTS.—(a) The columns must be anchored to the foundations by means of anchor bolts made of wrought iron or mild steel without upset ends.

(b) The diameter of bolt at root of thread must be such as to withstand the maximum uplift produced by the wind. No bolt shall be less than ¾-inch diameter. The bolts must also be of sufficient strength to resist the shearing force at the column footing.

(c) The bolts must have anchor plates not less than ½-inch thick under the nut and set in the foundation pier several inches above the bottom.

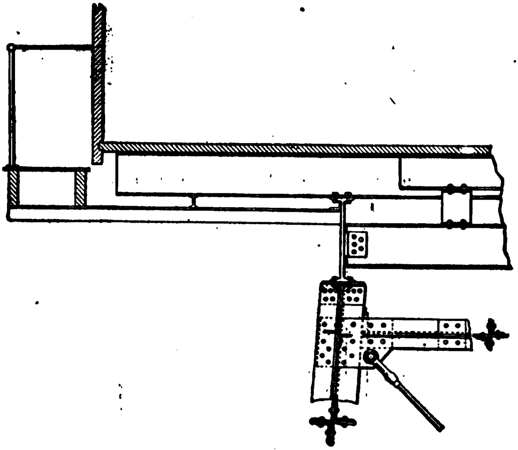


FIG. 103—Arrangement of Grillage

When structural steel shapes are used as plates they may be less than ½-inch thick.

51. WIND BRACING.—(a) The wind bracing may be made either of wrought iron or steel rods arranged for tightening or built up of riveted structural members.

(b) The rods may be either round or square and if provided with upset ends must comply with Franklin Institute standard and in no case have less than 15 per cent excess area at the root of the thread over the nominal cross section of the rod.

(c) The ends of the rods must be fitted with either clevis nuts or forked ends. Clevis nuts must be made to dimensions of the Cleveland City Forge and Iron Co. standard. The design of forked ends is shown in Figure 106 and the dimensions are given in the table.

(d) Rods having forked ends must have turn-buckles for tightening. All turn-buckles must be of the open type and made to dimensions of the Cleveland City Forge and Iron Co. standard.

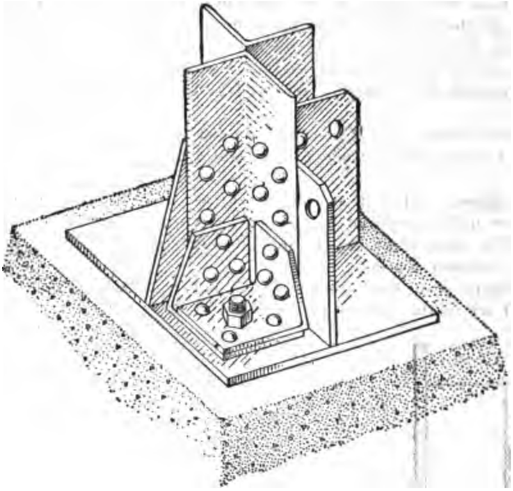


FIG. 104—Base Plate for Angle Post

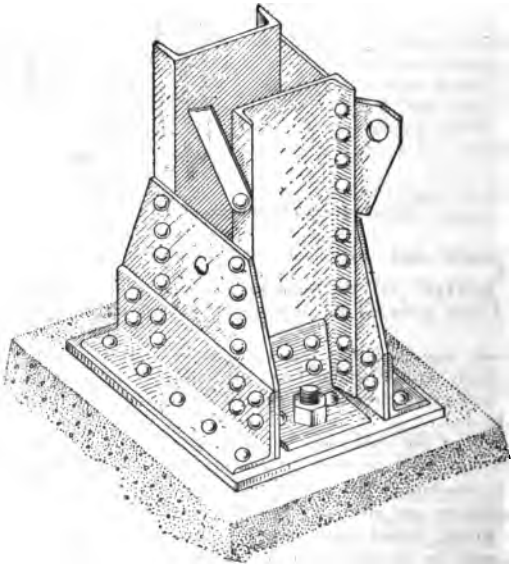


FIG. 105—Base Plate for Channel Post

(e) All screw threads must be made tight fits in the nuts and turn-buckles. They must be U. S. standard except for diameters greater than 1⅜ inches when they must have six threads per inch as follows:—

Diameter of screw ends,	1"	1⅛"	1¼"	1⅜" and greater
Number of threads per inch,	8	7	7	6

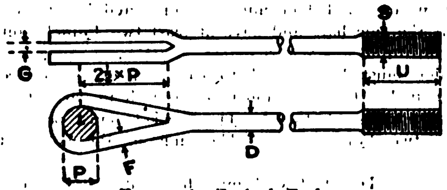


FIG. 106—Forked Ends

D	S	U	F
¾	1	4½	½
⅞	1⅛	4½	9-16
1	1¼	5	11-16
1⅛	1⅜	5	¾
1¼	1½	5½	13-16
1⅜	1¾	5½	⅞
1½	2	5½	1
1⅝	2⅛	5½	1 1-16

P should be made large enough to give a bearing stress for the pin not exceeding 20,000 pounds per square inch. G equals thickness of plate plus 1/16 inch.

52. PINS.—(a) The pins must be made of rolled steel.

(b) The pins must have a head on one end, and provided with a nut at the other end. They must be inserted downwards. It is advised that bolts be headed over the nut.

53. FOUNDATION PIERS.—(a) The piers must be pyramidical in shape, with full or stepped sides, and the height must be not less than the mean width.

(b) When columns are inclined, the piers must be designed so that the resultant of the vertical and horizontal forces due to direct loads shall pass through the center of gravity.

(c) The piers must be carried below frost line and the tops must be about 12 inches above ground.

In no case should earth or ashes be filled in about the steel work, as this might result in severe corrosion of it.

(d) The weight of the pier when buried for at least two-thirds of its height must be equivalent to the calculated net uplift; otherwise, the weight must be one and one-half times this amount.

(e) The piers must be constructed of concrete, consisting of one part Portland cement, three parts clean sand and five parts broken stone or gravel.

(f) The capstones, if constructed of concrete, must consist of one part Portland cement, one and one-half parts clean sand and three parts broken stone.

(g) The top of pier must be of such size that there will be at least 3 inches all around the base plate, as shown in Figures 104 and 105.

54. LADDERS.—(a) A steel ladder must be provided on one post extending from a point within easy reach from the ground to the balcony. It must not tip outward from the vertical at any point.

(b) The ladder must be constructed with not less than 2 x ⅝-inch flat side bars, spaced not less than 14 inches apart, and not less than ¾-inch round or ⅝-inch square rungs, spaced not more than 12 inches apart. The rungs must be riveted through slotted holes in the side bars to prevent their turning. The square rungs must be placed corner up.

(c) The sections of the ladder must be connected by single butt straps of the same size as the side bars and have at least two ½-inch bolts in each side of strap.

(d) The ladder must be secured to the post every 10 feet by flat bar brackets about 6 inches long, of sufficient strength to carry the weight of the ladder and 1,000 pounds additional. The brackets must be connected at each end by at least two ½-inch bolts. The ends of the bolts must be riveted over the nuts.

55. PAINTING.—(a) The steel work must be painted as directed in Article 36, items *a* and *b*.

56. LOADS.—(a) The dead load shall consist of the weight of the tank, structural and ornamental steel work, platforms, roof, piping, etc.

(b) The live load shall consist of the weight of the total volume of water, the movable load on the platform, and the wind load.

(c) The live load on the platform shall be assumed to be 30 pounds per square foot.

(d) The wind pressure shall be assumed to be 30 pounds per square foot acting in any direction. In calculating the wind load on the tank, this pressure is assumed to act on 6/10 the projected area of the tank including the roof, and in the case of steel tanks the hemispherical bottom.

(e) The total wind pressure on posts, struts, wind rods, ladders and riser boxing shall be assumed to be 200 pounds per foot of height of tower.

(f) All parts of the structure must be proportioned so that the sum of the dead and live loads shall not cause the stresses to exceed those which are allowable.

57. UNIT STRESSES AND PROPORTION OF PARTS.—The maximum stresses must not exceed the following amounts in pounds per square inch:—

Axial tension: on net section, wind and anchor rods	15,000
Plates	10,000
Axial compression on gross section of columns and struts	12,000

This stress shall be reduced by the formula 17,100—57$\frac{l}{2}$ where "l" is the unsupported length of the member from center to center of connections in inches, and "r" is the least radius of gyration of section in inches. The ratio $\frac{l}{2}$ must not exceed 125 for columns and 150 for struts and minor members.

Bending: on extreme fibres of rolled shapes, built sections, struts and steel castings; net section	16,000
Footing I beams set on brickwork or concrete; net section	12,000
Pins	20,000
Shearing: shop driven rivets and pins	10,000
Field driven rivets	7,500
Bolts	6,000
Plates	10,000
Bearing: shop driven rivets and pins	20,000
Field driven rivets	15,000

58. ALLOWABLE PRESSURES ON BEARING PLATES.—(a) In proportioning the size of bearing plates, the following allowable pressures, in pounds per square inch, should be used:—

Portland cement concrete	400
Sandstone (first class)	400
Limestone (first class)	500
Granite (first class)	600
Hard brick with Portland cement mortar	200

When bearing plate is to support tank above roof of building, the brick-work (hard brick) with Portland cement mortar should be figured on the basis of 125 pounds per square inch.

Allowable pressures on soil will range from 1 to 5 tons per square foot, depending on whether the soil is soft clay, ordinary clay, dry sand and clay, hard clay, or gravel and coarse sand.

PRESSURE TANKS

59. CAPACITY.—Total capacity of tank must be specified by the inspection department having jurisdiction.

Sizes less than 4,500 or over 9,000 gallons are not recommended. In cases where pressure tanks are the primary supply to dry-pipe systems it is advisable to provide a larger tank capacity than would be required for an equivalent number of sprinklers on a wet-pipe system.

60. LOCATION.—Tank not to be located below upper story of building.

61. TANK SERVICE.—Tanks to be used only as a supply to automatic sprinkler systems and hand hose.

62. CONSTRUCTION.—(a) Material. Must be of open hearth flange steel conforming to the American Society for Testing Materials Specifications. Each plate must have a test mark 12 inches from each corner and one in the center.

Thickness of plates of the cylindrical shell must be determined by the following formula:—

$$T = \frac{P \times r \times 5}{\% \times S}$$

T = Thickness of cylindrical shell plate in inches.
r = Radius of cylindrical tank.
5 = Factor of safety.
S = Ultimate tensile strength of steel.
P = Normal working pressure in pounds per square inch.
% = Efficiency of longitudinal seam.

(b) Heads. Thickness of heads must be determined by the following formula:—

$$T = \frac{P \times r \times 5}{0.6 \times S}$$

Radius of dish of head must be equal to the diameter of the tank.

In case of tanks of odd diameters the inspection department having jurisdiction may allow a variation of 3 inches either above or below the diameter.

Radius to be used in formula for heads to be the radius of the tank which is one-half the radius of the head.

Heads must be dished concave to the pressure. Corner radius of dished heads to be not less than one-sixteenth of the radius of the tank, the corner radius to be measured on the concave side of the head.

(c) *Seams*. Longitudinal seams must be butt joint, with inside and outside butt straps and placed below the water line. Not more than one seam is allowed in each course.

The minimum thickness of butt straps must be as follows:—

Thickness of Shell Plates	Minimum Thickness of Butt Straps	Thickness of Shell Plates	Minimum Thickness of Butt Straps
$\frac{1}{4}''$	$\frac{1}{4}''$	$\frac{17}{32}''$	$\frac{7}{16}''$
$\frac{9}{32}''$	$\frac{1}{4}''$	$\frac{9}{16}''$	$\frac{7}{16}''$
$\frac{5}{16}''$	$\frac{1}{4}''$	$\frac{5}{8}''$	$\frac{1}{2}''$
$\frac{11}{32}''$	$\frac{1}{4}''$	$\frac{3}{4}''$	$\frac{1}{2}''$
$\frac{3}{8}''$	$\frac{5}{16}''$	$\frac{7}{8}''$	$\frac{5}{8}''$
$\frac{13}{32}''$	$\frac{5}{16}''$	$1''$	$\frac{3}{4}''$
$\frac{7}{16}''$	$\frac{3}{8}''$	$1\frac{1}{8}''$	$\frac{3}{4}''$
$\frac{15}{32}''$	$\frac{3}{8}''$	$1\frac{1}{4}''$	$\frac{7}{8}''$
$\frac{1}{2}''$	$\frac{7}{16}''$	...	...

Butt straps to be rolled or formed to the proper curvature on forms made for that purpose. Maximum length of continuous longitudinal joint not to exceed 12 feet. Girth seams may be lap joint, single riveted, but must have a factor of safety of at least 5.

Rivets. Rivet steel to conform to the American Society for Testing Materials Specifications for Rivet Steel. On longitudinal joints, the distance from the center of the rivet hole to the edge of the plate, except rivet holes in the ends of butt straps, shall not be less than 1½ times the diameter of the rivet hole. Rivet holes must be drilled in place, or punched ⅛ inch smaller and reamed to size. Seams must be caulked tight outside under test pressure. All caulking must be done by a round nose tool.

In calculating the efficiency of seams, unless data is available from actual tests of materials, the following constants are to be used:—

Ultimate tensile strength of steel plate, lbs. per sq. in.	55,000
Ultimate crushing strength of steel plate, lbs. per sq. in.	95,000
Shearing strength of rivets:—	
Iron rivets in single shear	38,000
Iron rivets in double shear	70,000
Steel rivets in single shear	42,000
Steel rivets in double shear	78,000

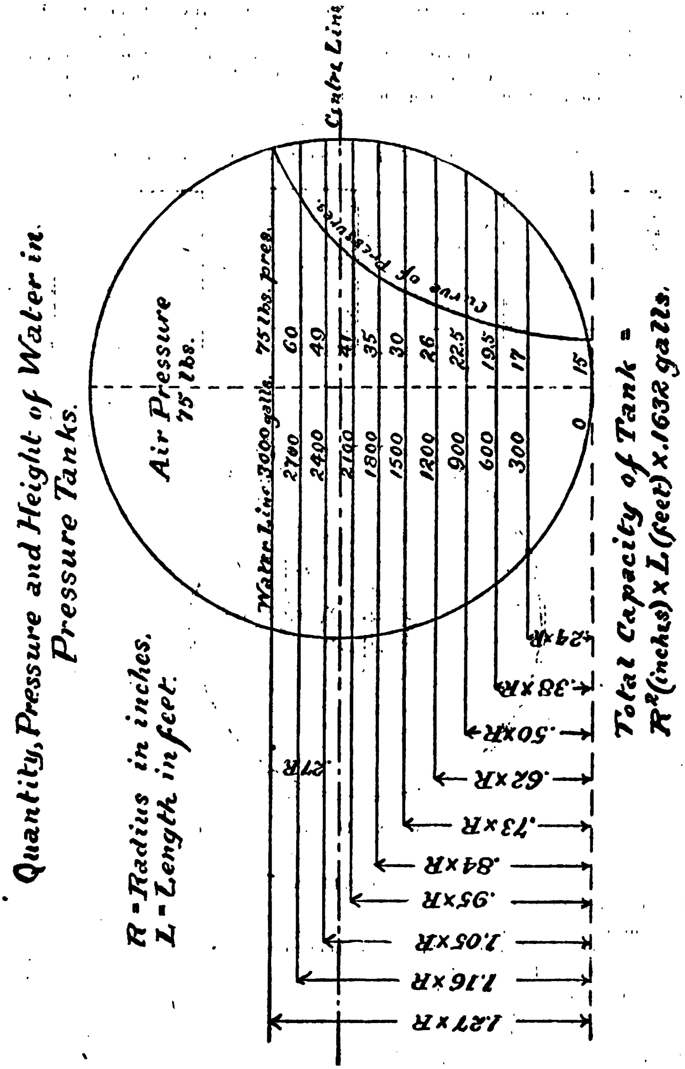
(d) Manhole. Must be placed below the water line, and not exceed 11 x 15 inches in size. The manhole frame or other reinforcing ring should be of wrought iron or cast steel, and have a net cross sectional area, on a line parallel to the axis of the shell, not less than the cross sectional area of the shell plate removed on the same line, and this reinforcement should be at least as thick as the shell plate. The strength of the rivets in shear on all manhole frames and reinforcing rings must be not less than the tensile strength of the plate removed, on a line parallel to the axis of the shell, through the center of the manhole. The short axis of the manhole opening must be parallel with the axis of the shell, to facilitate reinforcement.

(e) Outlet and Other Openings. Discharge fitting must be placed in the bottom of the tank projecting 2 inches within the tank to prevent sediment depositing in the sprinkler pipes. Fitting may also be used for connecting the 1½-inch water filling pipe to the tank. Inlet for air supply to be 1 inch, and placed at proper point for upper gauge glass nipple, where suitable connections can be made for both purposes; or 2-inch inlet may be made at a proper point above the water line into which both the 1½-inch water filling pipe and the 1-inch air filling pipe may connect to proper valves to be provided, as noted in Rule 64 d.

Brass nipples must be provided for these inlets and also for the ¾-inch fitting needed to complete the gauge glass connections. An approved automatic valve must be provided at each end of gauge glass. A 2-inch nipple extending at least 6 inches into tank should also be provided at the end of water inlet, to prevent surging or "foaming" of water when tank is being filled. Any opening for a threaded pipe connection 1 inch in diameter or over must have not less than the minimum number of threads in such opening, as shown in the following table:—

Size of pipe connection in inches	1" and 1¼"	1½" and 2"	2½"–4"	4½"–6"
Number of threads per inch	11½	11½	8	8
Minimum number of threads required in opening	4	5	7	8
Minimum thickness of material required to give above number of threads	.348"	.435"	.875"	1"

If the thickness of the material in the tank is not sufficient to give such number of threads, there shall be a standard commercial pressed or cast



PRESSURE TANK FOR SPRINKLER SYSTEM

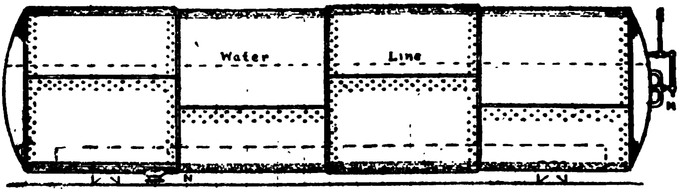
steel flange or steel plate, substantially riveted to the tank so as to give the required number of threads.

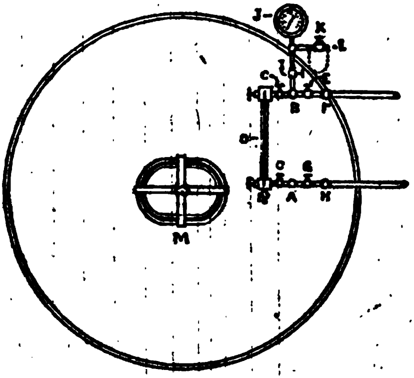
Size of discharge must be 4 inches in tanks up to 5,000 gallons capacity and must be 6 inches for larger sizes.

There should be a swing joint in discharge pipe directly under or near the tank.

63. **TEST.**—Tank must be tested at the shop and proved tight at a hydrostatic pressure of at least 50 per cent in excess of the normal working pressure required. After erection, the tank, two-thirds full of water, must be tested at the working air pressure required. In this condition and with all valves closed, tank must not show loss of pressure in excess of ½ pound in 24 hours.

PRESSURE TANK FOR SPRINKLER SYSTEM





END VIEW AND DETAIL OF PIPING

NOTATION

A connection from tank.
B connection from tank.
C shut-off valves of best quality, to be kept closed.
D water gage of best quality.
E shut-off valve of best quality.
F check valve of best quality.
G shut-off valve of best quality.
H check valve of best quality.
I shut-off valve of best quality, to be secured open.
J dial pressure gage of best quality reading to 150 lbs.
K shut-off valve of best quality, to be secured closed.
L brass plug secured by chain; opening is for testing gage.
M man-hole.
N discharge outlet for connection to sprinkler system.

TABLE OF HEIGHT OF WATER IN HORIZONTAL CYLINDRICAL PRESSURE TANK

Tank two-thirds full

Diameter Tank in Inches	Height in Inches
56	35¼
57	36
58	36½
59	37¼
60	38
61	38½
62	39¼
63	39¾
64	40½
65	41
66	41¾
67	42¼
68	43
69	43¾
70	44¼
71	45
72	45½
73	46
74	46¾
75	47½
76	48

Pressure tanks can be made at any boiler works.

64. **Fittings and Connections.**—(a) **Gauge Glass. Must be placed on the end of horizontal and side of upright tank so that the two-thirds line will be at the center of the glass. Gauge glass valves must be of the best quality angle globe pattern.**

The two valves in the water gauge connections to be of approved automatic type and to be kept closed, and opened only to ascertain the amount of water in the tank, as breaking of or leakage about glass will cause the escape of pressure.

(b) Pressure Gauge. Must be placed directly on the upper gauge glass nipple and provided with a separate shut-off valve.

(c) Filling Point. Tank must be kept two-thirds full of water and have a fixed metallic horizontal line opposite gauge glass, indicating this water level. A conspicuous sign indicating minimum air pressure allowed should be stamped on the fixed metallic plate indicating the water level.

For horizontal tanks the two-thirds line to be determined by the following formula: Distance above the bottom equals 1.265 x radius of tank in inches.

(d) Filling Pipes. Water for supplying tank must be conveyed through fixed iron piping not less than 1½ inch in size. Sprinkler piping not to be used for this purpose.

Pipe from air pump must be at least 1 inch in diameter, connect with tank above the water level, and must be independent of water supply pipe, except as noted under Section 62e.

See also Section 68 as to safety valve.

(e) Drain Pipe. Provision must be made to drain each tank independently of other tanks and the sprinkler system by a pipe not less than 1½ inches in diameter.

The practice of placing drain valves at lower levels and accessible from the exterior of buildings is not approved.

65. **Pressure.**—When the bottom of the tank is located on a level with the highest sprinklers an air pressure not less than 75 pounds should be maintained in order that a pressure of not less than 15 pounds will be

furnished at the highest line of sprinklers when all water has been discharged from the tank.

When the bottom of the tank is located lower than the highest sprinklers a pressure in excess of 75 pounds should be maintained. This excess pressure must be equal to three times the pressure, due to the height of the sprinklers above the bottom of the tank.

66. FILLING.—Arrangements must be made for filling the tank so that the proper water level may be restored at any time without reducing the air pressure.

67. MAINTENANCE.—Tank must be painted inside and outside, with a good quality of lead paint, must be cleaned, scraped and repainted when necessary. Tank must have a hydrostatic pressure test similar to one noted in Section 63, once in two years.

68. AIR COMPRESSOR.—A steam or electrically driven air compressor having sufficient capacity to increase the air pressure at an average rate of at least one pound in two minutes should be provided.

A properly designed safety valve must be installed at the air compressor, or in the pipe from it to tank, so that an excessive air pressure may not be pumped into tank.

Where the compressor is also used to maintain dry-pipe systems, the air supply should be taken from the outside or from a room having dry air. in order to avoid carrying moisture into the pipe system. The intake should be protected by a screen.

69. TANK HOUSE.—Tank must be properly protected from frost, and if located above the roof must be enclosed in a house of substantial construction, of easy access, and of ample size to provide free access on all sides. Must be arranged so that it can be properly lighted at all times.

There should be a space at least 3 feet at end where gauges are located and a window should be provided opposite gauges.

Tank house must be constructed in accordance with the requirements of municipal or building authorities where they exist.

70. SUPPORTS FOR TANKS.—Tank to rest on a cradle of cast iron, concrete or other equally rigid material which will prevent possible sagging or vibration. Wood is not approved for this purpose. Supports must be proportioned so as to safely carry the load, using a factor of safety of at least four, and must be installed under the requirements of the municipal or building authorities where they exist.

TANKS ON BUILDINGS.

(a) Tanks should be located on buildings only when this is absolutely necessary as tanks so located are a menace to life and property unless the best of care is taken regarding the supports.

(b) Before supporting a tank on a building great care should be taken to make sure that the building is strong enough to carry the extra weight that the tank imposes.

(c) In a building about to be erected special arrangements for the tank should be made in the plans of the building itself. With buildings already constructed it is necessary to have an expert pass on the strength of the supports. It will often be desirable to arrange for the required capacity by two tanks instead of one.

(d) Tanks on buildings should be supported either by steel beams laid across brick, stone or concrete walls, carried above the roof to the necessary height or by a substantial trestle of the necessary height built in accordance with preceding rules so far as they apply.

If a trestle is used it should be supported entirely by brick, stone or concrete walls, posts or piers. If the tank is supported wholly or in part by steel columns within a building, these should be riveted and fireproofed. An exception to this is in case the whole building is of wood, when a tank may be supported by wood columns only by special permission of the inspection department having jurisdiction.

(e) In designing trestle footings for tanks on buildings the safe load on any brick work must not be figured at over 125 pounds per square inch. The trestle should be strongly and securely anchored to the building to guard against any possible overturning due to the action of the wind when the tank is empty.

Special attention is called to the necessity of safeguarding against corrosion at the point where steel supports pass through the roof.

CONCRETE RESERVOIRS*

See Figures 107 to 110 inclusive.

Concrete work should be entrusted only to experienced and responsible parties, as even the best material will give poor results unless properly used.

Workmanship should be first class and in conformity with best engineering practice.

The time of construction should be chosen so as to avoid freezing weather, as concrete is likely to be unsatisfactory and unsafe if laid when temperature is below freezing unless great precautions are taken.

Specifications for Reservoirs

It is believed that concrete proportioned for maximum density, properly reinforced and carefully mixed and placed is the best material that can be used for water-tight reservoirs. Either rectangular or circular form may be used. The circular form admits of a more economical arrangement of reinforcement and gives the greatest resistance against both external and internal pressure.

1. MATERIALS.—1. The cement shall be Portland cement, and shall meet the requirements of the Standard Specifications of the American Society for Testing Materials.

2. The aggregate shall be sand and stone or other hard durable material. Frozen material must never be used. Both sand and stone to be free from dust, loam, vegetable or other organic matter.

(a) Fine Aggregate. Fine aggregate shall consist of sand, crushed stone or gravel screenings, graded from fine to coarse and passing, when dry, a screen having one-quarter (¼) inch diameter holes, and not more than three (3) per cent passing a sieve having one hundred (100) meshes per linear inch.

(b) Coarse Aggregate. Coarse aggregate shall consist of crushed stone, gravel or similar material, graded in size, retained on a screen having one-quarter (¼) inch diameter holes and the maximum size which shall be such as to pass a one and one-quarter (1¼) inch ring.

Natural mixed aggregates shall not be used as they come from the deposit but shall be screened and remixed to agree with the proportions specified.

3. Water shall be free from oil or excess of acid, alkali or vegetable matter.

4. The reinforcing metal shall meet the current requirements of the Standard Specifications for Steel Reinforcement of the American Railway Engineering Association.

2. FOUNDATIONS.—5. Average earth, except loam, will safely support from two to four tons per square foot. In doubtful cases the service of a competent engineer should be secured and a proper foundation specified by him.

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* Regulations prescribed by National Board of Fire Underwriters.

3. SUB-GRADE.—6. Depth. (a) If a sub-base is required, the sub-grade shall not be less than eleven (11) inches below the finished surface of the floor.

(b) If a sub-base is not required, the sub-grade shall not be less than five (5) inches below the finished surface of the floor.

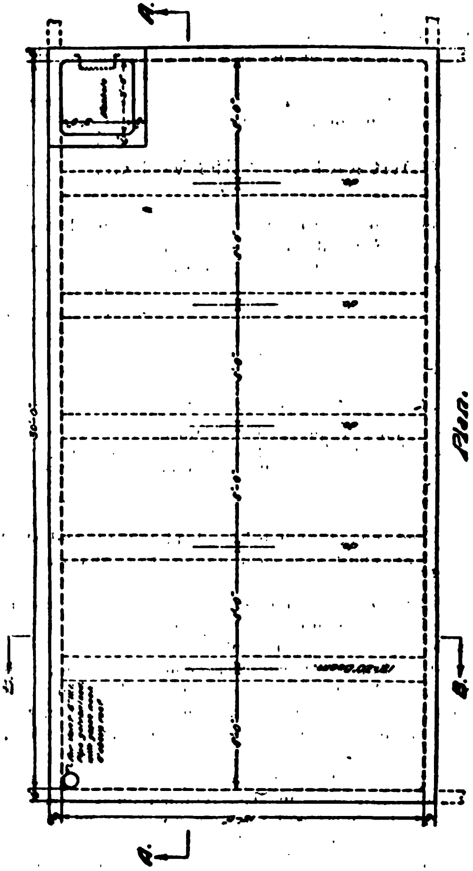


FIG. 107

CONCRETE RESERVOIR.

7. Preparation of Surface. All soft and spongy places shall be removed and all depressions filled with suitable material which shall be thoroughly compacted in layers not exceeding six (6) inches in thickness.

8. Drainage. When required, a suitable drainage system shall be installed.

4. SUB-BASE.—9. The sub-base shall consist of a layer of suitable material, clean and hard, and not exceeding four (4) inches in the largest dimension. To be spread on the sub-grade and rolled or tamped to a surface at least five (5) inches below the finished grade of the floor.

10. Wetting. While compacting the sub-base, the material shall be kept thoroughly wet, and shall be in that condition when the concrete is deposited.

5. CONSTRUCTION.—11. The forms shall be substantial, unyielding and so constructed that the concrete will conform to the designed dimensions and shall also be tight to prevent the leakage of mortar. The forms shall not be removed in less than ten (10) days after the concrete is placed, and then only with the consent of the engineer in charge.

12. The reinforcement shall be free from rust, scale or coatings of any character which will tend to reduce or destroy the bond, and shall be placed and held in position so that it will not become disarranged during the depositing of the concrete.

13. Joints in Concrete. For concrete construction it is desirable to place the entire structure at one operation, but as this is not always possible, especially in large structures, it is necessary to stop the work at some convenient point. This point should be selected so that the resulting joint may have the least possible effect on the strength of the structure. It is therefore recommended that the joints in columns be made flush with the lower side of the girders; that the joints in girders be at a point midway between supports, but should a beam intersect a girder at this point, the joint should be offset a distance equal to twice the width of the beam; that the joints in the members of a floor system should in general be made at or near the center of the span.

14. Joints in columns should be perpendicular to the axis of the column, and in girders, beams, and floor slabs perpendicular to the plane of their surfaces.

15. Joints in Reinforcement. Wherever it is necessary to splice tension reinforcement, the length of lap should be determined on the basis of the safe bond stress, the stress in the bar, and the shearing resistance of the concrete at the point of splice; or a connection should be made between the bars of sufficient strength to carry the stress. Splices at points of maximum stress should be avoided. In columns, bars more than ¾-inch in diameter, not subject to tension, should be properly squared and butted in a suitable sleeve; smaller bars may be treated as indicated for tension reinforcements, or the stress may be cared for by embedment in large masses of concrete. At foundations, bearing plates should be provided for supporting the bars, or the bars may be carried into the footing a sufficient distance to transmit the stress of the steel to the concrete by means of the bearing and bond resistance; in no case shall the ends of the bars be permitted merely to rest on concrete.

6. MEASURING AND MIXING.—16. The materials for the concrete, including water, to be measured separately in such a manner as to insure uniform proportions at all times. A bag of Portland cement (94 lbs. net) shall be considered one (1) cubic foot.

17. The ingredients of the concrete or mortar shall be thoroughly mixed dry, sufficient water added to obtain the desired consistency and the mixing continued until the materials are uniformly distributed and the mass is homogeneous and uniform in color.

(a) Machine Mixing. When the conditions will permit, a machine mixer of a type which insures the uniform mixing of the materials, shall be used.

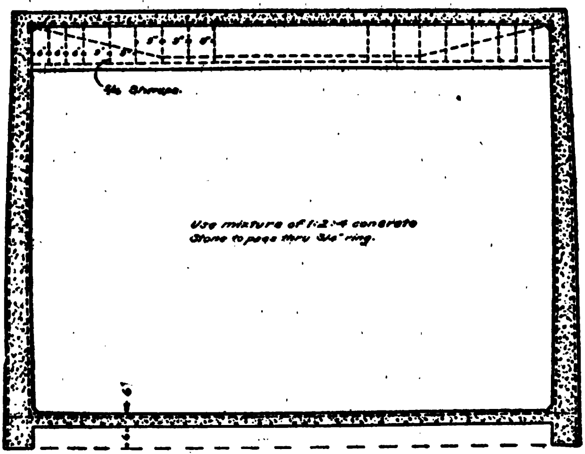
(b) Hand Mixing. When it is necessary to mix by hand, the mixing shall be on a water-tight platform and according to the above requirements.

18. Retempering, that is, remixing mortar or concrete that has partially hardened with additional water, will not be permitted.

7. FLOORS.—19. Thickness. The floors shall be thick enough to stand the necessary strains and in no case have a thickness of less than four (4) inches.

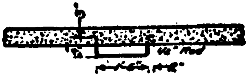
20. Proportions. The mixture of concrete shall be as rich as the following (by volume), one (1) part Portland cement, two (2) parts fine aggregate, and four (4) parts coarse aggregate.

21. Consistency. The materials shall be mixed wet enough to produce a concrete of a consistency that will flow into the forms and about the reinforcement, but which can be conveyed from the mixer to the forms without the separation of the coarse aggregate from the mortar.



Section B-B.

CONCRETE RESERVOIR.



Ladder Rung

FIG. 108

22. Placing. The concrete shall be placed in a manner to insure a smooth surface, and thoroughly worked around the reinforcement and into the recesses of the forms. It shall be brought to a surface at least one (1) inch below the finished surface of the floor, and before it has dried out ,the wearing course shall be applied. Workmen shall not be permitted to walk on freshly laid concrete, and if sand or dust collects on the base, it shall be carefully removed before the wearing course is applied.

23. Wearing Course, Proportions. The mortar shall be mixed in the

manner hereinbefore specified in the proportion of one (1) part Portland cement and not more than two (2) parts fine aggregate.

24. Wearing Course, Consistency. The mortar shall be of a consistency that water will flush to the surface only under heavy, thorough working with a wood float.

25. Wearing Course, Thickness. The wearing course of the floor shall have a thickness of at least one (1) inch.

26. Wearing Course, Placing. The wearing course shall be placed immediately after mixing.

27. Wearing Course, Finishing. After the wearing course has been brought to the established grade, it shall be worked with a wood float in a manner which will thoroughly compact it. When required, the surface shall be troweled smooth, but excessive working with a steel trowel shall be avoided. If excessive moisture occurs on the surface, it must be taken up with a rag or mop, and in no case shall dry cement or a mixture of dry cement and sand be used to absorb this moisture or to hasten the hardening.

8. SUMP.—28. A sump consisting of a recess at least three feet square and three feet deep to be located so as to come under manhole in roof. The surface of the floor to be carefully graded to produce a uniform pitch to the sump.

9. WALLS.—29. Proportions. (Same as floors.)

30. Walls to be properly designed to resist the stresses to be sustained with reservoir full or empty. Thickness to be not less than four (4) inches.

31. They shall be built true to planes by means of suitable forms, securely braced against movement.

32. The surface next to forms shall be thoroughly spaded by means of a suitable spading tool so as to insure a smooth face when the forms are removed. Care shall be exercised to prevent disturbing the position of the reinforcing metal during the placing of concrete.

33. Where sections of walls are stopped during construction, a groove shall be formed in the face of the joint. On joining the next succeeding section, the face of the joint shall be carefully cleaned with water and coated with neat cement.

34. A permanent ladder to be provided from top to floor of reservoir.

10. ROOF AND COLUMNS.—35. Proportions. (Same as floors.)

A covered reservoir is preferable to an open one, as it is stronger, less liable to freeze, and water is kept cleaner. If it is desired to omit the roof, permission should be obtained from the inspection department having jurisdiction. Where no cover is used, suitable provision should be made to prevent excessive freezing.

36. Roof and columns to be properly designed to fit existing conditions.

37. If reservoir is completely roofed over, a trap door at least 20 by 26 inches to be provided in the roof so arranged as to be easily opened. Permanent ladder to be accessible from this opening.

38. The forms for the entire roof should preferably be built so that the placing can be done in one operation.

11. FINISH.—39. Should porous or void spaces appear when the forms are removed, the same shall be cut out until solid work is exposed, and the hole thus made filled with a mixture of rich cement mortar.

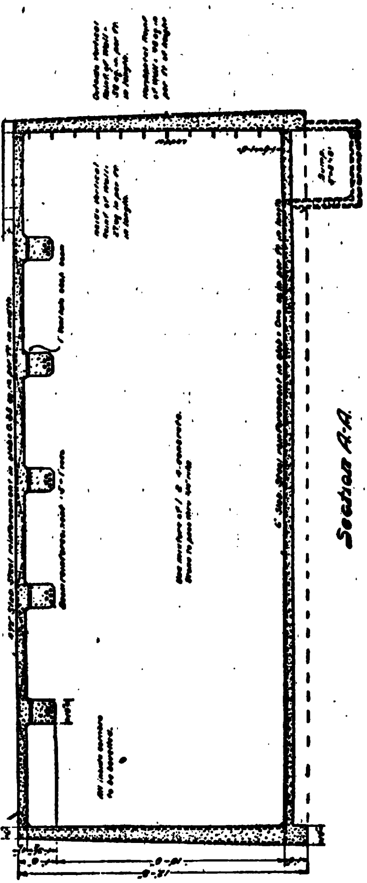
40. When the reservoir is completed, it shall be cleaned out, and the walls washed with two coats of cement wash applied to the entire walls and floors. Additional means of waterproofing may be used if desired.

12. LEAKAGE.—41. Leakage for the first 24 hours after filling shall not be more than 5 per cent of the total reservoir capacity. If more than 5 per

cent, water to be drawn off and porous concrete cut out and spaces filled with rich cement mortar.

42. Reservoir must be substantially water-tight after having been filled with water 14 days.

13. WORKING STRESSES.—43. Concrete composed of materials meeting the requirements of these regulations shall develop a compressive strength at 28 days equal to that given in the following table for the respective proportions and materials used, when tested as 8-inch diameter cylinders 16 inches long under laboratory conditions of manufacture and storage, using the same consistency as is used in the field:



Section A-A

CONCRETE RESERVOIR

FIG. 109

TABLE OF COMPRESSIVE STRENGTHS OF DIFFERENT MIXTURES OF CONCRETE
(In Pounds per Square Inch)

AGGREGATE	1:1:2	1:1½:3	1:2:4	1:2½:5	1:3:6
Granite, trap rock	3300	2800	2200	1800	1400
Gravel, hard limestone and hard sandstone	3000	2500	2000	1600	1300
Soft limestone and sandstone	2200	1800	1500	1209	1000
Cinders	890	700	600	500	400

For variations in the moduli of elasticity see Paragraph 53.

On this basis the following stresses, given in the form of percentages of the compressive strength of the concrete to be used, shall be allowed in construction:

a. Bearing compression, 32.5 per cent of the compressive strength.

b. Compression in extreme fibre, 32.5 per cent of the compressive strength. With increase of 15 per cent near supports in continuous beams.

c. Axial compression in columns without hoops, 22.5 per cent of the compressive strength and 6,750 pounds per square inch on vertical reinforcement.

d. Axial compression in columns with 1 per cent of hooping, 27 per cent of the compressive strength, and 8,100 pounds per square inch on vertical reinforcement.

e. Axial compression in columns with 1 per cent of hooping and 1 to 4 per cent of vertical reinforcement, 32.5 per cent of the compressive strength and 9,750 pounds per square inch on the vertical reinforcement.

44. The bars in the base of columns shall bear on a plate or casting, or shall be enlarged so as to reduce the bearing stress at the bottom to the stress given in paragraph 43a. In lieu of plate or the enlargement for bearing, the stress may be distributed to the footing by means of dowels with flat upper ends, length of the dowels being sufficient to distribute the stress by means of the bond of the dowel.

45. In the footing, the concrete bond stress to be as given in paragraph 50. The footings supporting columns where hooping vertical reinforcement is used shall be enlarged at the top to at least six inches on each side of the column, measurements being taken from the hooping.

46. Bars composing longitudinal reinforcement in columns shall be straight and shall have sufficient lateral support to be securely held in place until the concrete is set.

47. The clear spacing of bands or hoops shall not be greater than one-fourth the diameter of the enclosed column. Adequate means must be provided to hold bands or hoops in place so as to form a column, the core of which shall be straight and well centered.

48. Bending stresses due to eccentric loads must be provided for by increasing the section until the maximum stress does not exceed the values above specified.

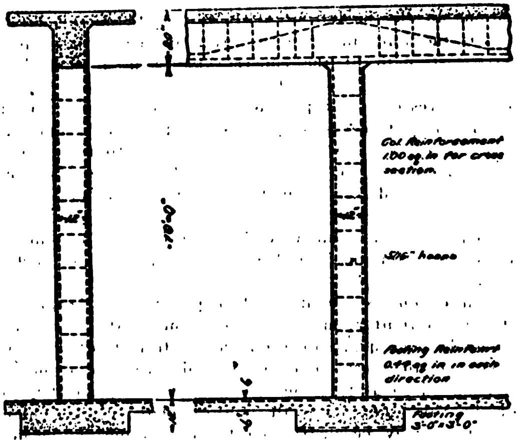
49. Compression on columns reinforced with structural steel units which thoroughly encase the concrete core, 27 per cent of the compressive strength of the concrete and 8,100 pounds per square inch on the structural steel.

50. Web stresses. In calculating web reinforcement the concrete shall be considered to carry 2 per cent of the compressive strength of the concrete, the remainder to be provided for by means of reinforcement in tension.

51. Members of web reinforcement shall be imbedded in the compression portion of the beam so that adequate bond strength is provided to fully develop the assumed strength of all shear reinforcement. They shall not be spaced to exceed three-fourths (¾) of the depth of the beam in that portion where the shearing stresses exceed the allowable shearing value of the concrete. Web reinforcement, unless rigidly attached, shall be placed

at right angles to the axis of the beam and looped around the extreme tension member.

52. Bond between plain bars and concrete, 4 per cent of the compressive strength of the concrete of surface of bar; where adequate mechanical bond is provided the stress shall not exceed 7.5 per cent of the compressive strength of the concrete.


8"
10'-0"
Col. Reinforcement 1.00 sq. in. for cross section.
5/16" hoops
Footing Reinforcement 0.44 sq. in. in each direction
Footing 3'-0"×3'-0"

Detail of Column.

CONCRETE RESERVOIR.

Notes:

Safe live load on roof 500 lbs per sq. ft.
With 9'-0" water level each 5'-0" section on plan has a capacity of 5000 gallons
Reservoir may be extended in width by 15'-0" units, using Interior Columns, or in length by using 5'-0" sections.
Sump should be located directly under manhole. Both may be located at any convenient point in reservoir.
Inside walls and floor to be treated with an application of cement wash.

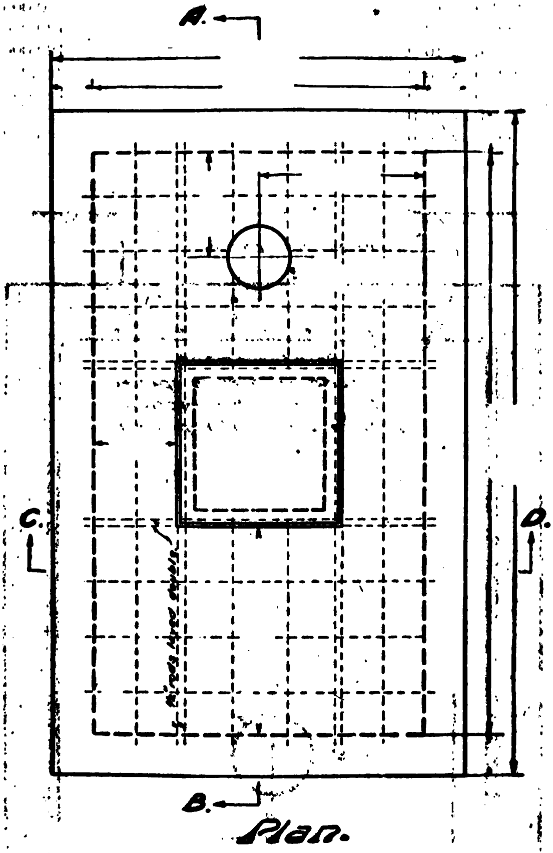
FIG. 110

53. The ratio of moduli of elasticity of concrete to steel shall be considered as 1:15 when the strength of the concrete is taken as less than 2,200 pounds per square inch; or 1:12 when taken between 2,200 and 2,900 pounds per square inch; or 1:10 when taken over 2,900 pounds per square inch.

54. The allowable tensile stress in reinforcement to be 15,000 pounds per

square inch for medium steel and 20,000 pounds per square inch for high elastic limit steel with adequate mechanical bond.

55. **Size and capacity.** Conditions vary so greatly that no definite requirements for dimensions can be laid down. The depth should not exceed 15 feet and preferably should be 10 feet.



VALVE PIT.

FIG. 111

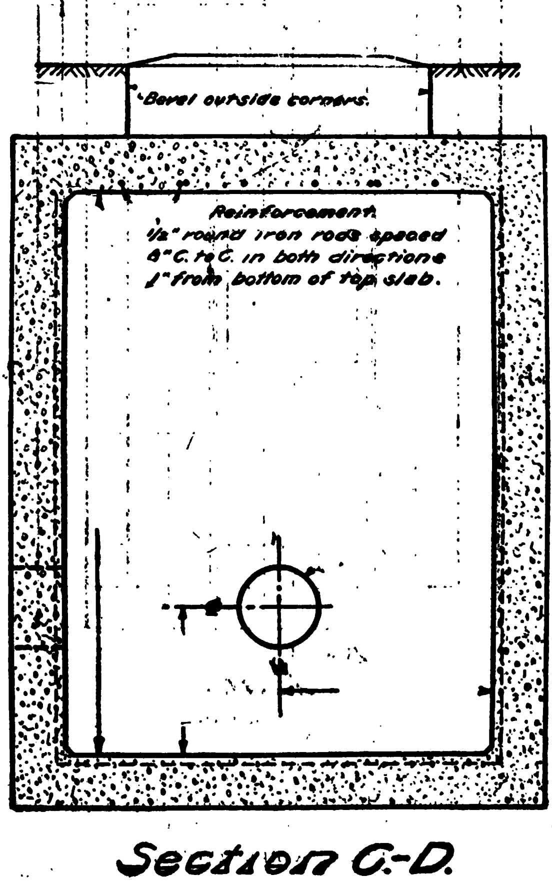
The following sizes and capacities are suggested, and in most cases will prove the most economical, for the reason that contractors may use standard forms, thereby reducing the cost of construction.

CIRCULAR RESERVOIRS

	Capacity
33 ft. diameter by 10 ft.	60,000 gals.
46 ft. diameter by 10 ft.	120,000 gals.
56 ft. diameter by 10 ft.	180,000 gals.
64 ft. diameter by 10 ft.	250,000 gals.

RECTANGULAR RESERVOIRS

Dimensions	Capacity
15 ft. x 60 ft. x 10 ft.	60,000 gals.
15 ft. x 120 ft. x 10 ft.	120,000 gals.
15 ft. x 180 ft. x 10 ft.	180,000 gals.
15 ft. x 240 ft. x 10 ft.	240,000 gals.
30 ft. x 60 ft. x 10 ft.	120,000 gals.
30 ft. x 90 ft. x 10 ft.	180,000 gals.
30 ft. x 120 ft. x 10 ft.	240,000 gals.
45 ft. x 60 ft. x 10 ft.	180,000 gals.
45 ft. x 75 ft. x 10 ft.	240,000 gals.
60 ft. x 60 ft. x 10 ft.	240,000 gals.


Bevel outside corners.
Reinforcement
1/2" round iron rods spaced
6" C. to C. in both directions
1" from bottom of top slab.
Section C.-D.

VALVE PIT.

FIG. 112

VALVE PITS*

See Figures 111, 112 and 113.

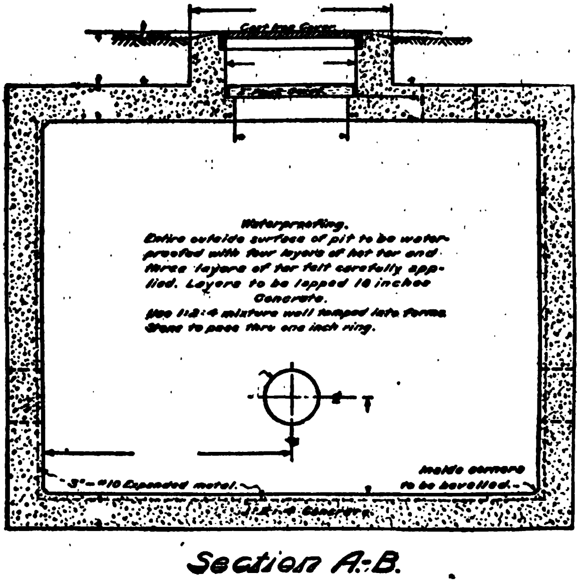
The rules for materials, mixtures, forms, etc., given for large reservoirs, also apply to small reservoirs and valve pits.

1. **Size.**—The size should be ample so that there will be a space of at least 12 inches around all valves.

2. **Floor.**—Concrete to be at least 4 inches thick and reinforced with metal lathing or rods.

3. **Walls.**—Walls to be of concrete at least 4 inches thick and reinforced in a similar manner to floor.

4. **Roof.**—a. To be not less than 6 inches thick and properly reinforced to carry load to which it is liable to be subjected.


Cast Iron Cover
2" Plank Cover
Waterproofing.
Entire outside surface of pit to be waterproofed with four layers of hot tar and three layers of tar felt carefully applied. Layers to be lapped 18 inches
Concrete.
Use 1:2:4 mixture well tamped into forms
Stone to pass thru one inch ring.
3"—#10 Expanded metal.
Inside corners to be bevelled.
1:2:4 Concrete.
Section A:B.

VALVE PIT.

FIG. 113

b. A standard manhole cover to be placed in the top of each pit. Six inches below the iron cover a second cover of 2-inch plank to be placed on a ledge formed in the concrete. Ledge to be at least 2 inches wide. In regions where extremely cold weather occurs it is advisable to fill pit with suitable insulating material, such as hay or straw.

5. **Drainage.**—If thought necessary in suitable soil such as sand and gravel, drainage hole may be provided. To be at least 4 inches in diameter.

6. **Waterproofing.**—If a waterproof pit is necessary, as in water-bearing ground, the entire outside surface of pit should be thoroughly waterproofed. The following method is advised. Surface to be painted with hot tar or asphalt and then covered with at least two layers of tarred felt and hot tar or asphalt alternately. Felt to be lapped 18 inches.

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* Regulations prescribed by National Board of Fire Underwriters.

CONCRETE TANKS*

Where there are building ordinances or special regulations by municipal authorities relating to the construction of tanks or structures, they are to be followed except that when such ordinances permit of a weaker construction than is herein specified, these requirements should be followed.

Concrete would probably not be used except for tanks of considerable size and the design and construction should be entrusted only to competent engineers.

The design of concrete tanks should in general follow the requirements for concrete reservoirs, but as the field experience with such tanks is very limited it is not deemed desirable to give detailed specifications.

1. REINFORCEMENT.—a. Tank to be reinforced so that all tensile stress shall be borne by the reinforcing metal.

b. Radial bars at least eight feet long to be embedded in floor and carried up at least four feet into the walls. Bars to be at least ⅝-inch in diameter and to be spaced not over 12 inches at the circumference of tank.

c. Horizontal hoops in walls from the floor to a height of three feet shall not have a stress of over 8,000 pounds per square inch with tank full. Above this point, stress may be increased gradually to not over 12,500 pounds.

d. Laps in hoops to be fastened mechanically so as to safely develop the working stress.

e. Hoops to be accurately spaced and supported so they cannot be moved out of place while concrete is being filled in. Reinforcement at top of tank to be designed to resist pressure from ice in case the tank freezes over.

f. All reinforcing metal to be covered by at least 1 inch of concrete.

2. WALLS.—a. Walls to be not less than 4 inches thick at any point.

b. Where inlet and outlet pipes pass through the wall, thickness to be increased to at least twice the normal thickness.

3. TIGHTNESS.—Tank to be tight, showing no leaks before being accepted.

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* Regulations prescribed by National Board of Fire Underwriters.

SPECIFICATIONS FOR THE CONSTRUCTION AND EQUIPMENT OF HOSE HOUSES FOR MILL YARDS

Standard Hose Houses.—The following specifications for Standard Hose Houses are now used throughout the whole country, having been agreed upon in joint conference by representatives of the different organizations interested in this class of work. They are known as "The National Standard" and have been, up to this time, adopted by the following associations:

Associated Factory, Mutual Fire Insurance Companies.
National Board of Fire Underwriters.
National Fire Protection Association.

The Standard Hose House specified herein provides an accessible place where the hose and the small equipment for mill yard fire protection may be assembled and kept ready for instant use.

Hose and appliances stored in towers or buildings may be made inaccessible by fire or smoke and the entire equipment of pump, water mains and hydrants thus rendered useless for hose service. Serious delay may also be occasioned by placing the hose and appliances at distant parts of the yard.

The increased efficiency, economy and the prolonged life of hose stored on slatted shelves in well ventilated houses, render the installation of properly equipped Standard Houses essential to a mill yard.

These specifications cover two types for a two or three-way hydrant, and one type for a four-way hydrant, having two lengths of attached hose. The latter house is seldom necessary, except between buildings or in the center of a plant where it may be of advantage to have the hose so attached that it can be run off in either direction without delay. The designs given for the two and three-way houses are practically those which have been used in some localities for a number of years. The Underwriters having jurisdiction should be consulted as to the best type for use in each individual case.

Construction

1. Location.—Houses to be located so that two or three-way hydrants will be as close to the front of the house as possible and still allow sufficient room back of the doors for the hose gates and attached hose.

2. Foundations.—To consist of a brick pier at each corner, 12 inches square and 8 inches high, above ground.

Note.—Depth of the foundation should be sufficient to prevent serious displacement by frost.

3. Material.—To be of good lumber, free from injurious knots, and

seasoned to prevent serious warping. Sheathing, roof and doors to be of ⅞-inch matched stuff dressed on one side.

4. SIZE.—Frame to be 6 feet 4 inches wide, 6 feet deep and about 7 feet high, for two or three-way hydrants, and 8 feet square and 7 feet high for four-way hydrants. See Figs. 115 and 118.

5. FRAME.—To be made of 2 x 3, 2 x 4 and 3 x 4 inch material, constructed as illustrated in Figs. 116 and 119.

6. ROOF.—To be made weather-tight by tinning or its equivalent and to be properly inclined for drainage.

NOTE.—The ornamental roof shown in Fig. 120 or 121 may be used if desired.

7. DOORS.—a. To be in pairs, to open the full width of the front, to be hung on heavy tee hinges bolted on and to swing one foot clear of the ground.

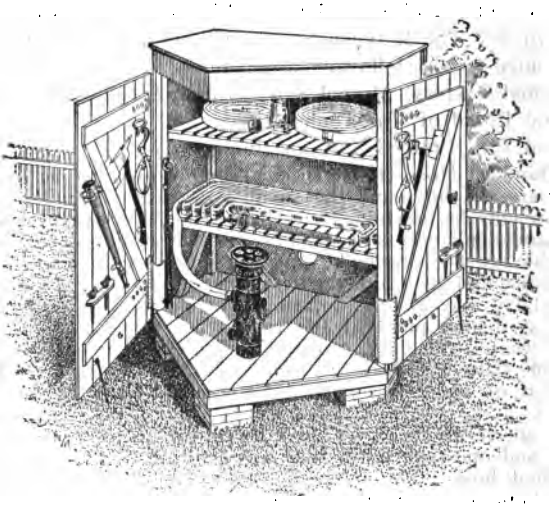


FIG. 114

b. To be provided with substantial battens at top and bottom and a suitable diagonal cross brace well nailed on. Nails to be clinched.

NOTE.—Care should be taken to select well-seasoned stuff in order to prevent warping. Extra wide battens and cross-braces should also be used.

c. Two sets of doors opening on opposite sides to be provided when the four-way hydrant is used. See Fig. 120.

8. HOSE SHELVES.—a. To be made of 3-inch slats ⅞-inch thick and spaced ½-inch apart and supported as shown in Figs. 115, 118 or 120.

NOTE.—The object of the slats is to permit the circulation of air around the hose. The spacing named should not be exceeded, as the hose is liable to catch in wider openings.

b. Two shelves supported on the horizontal framing and extending across the house to be provided when the two or three-way hydrant is used.

NOTE.—The lower shelf is designed to hold 100 feet of hose attached to the hydrant. The upper shelf is designed to hold the spare hose.

c. Three shelves supported on one side and extending from door to door to be provided where the four-way hydrant is used. Shelves to be provided with 6-inch sideboards and the two lower shelves to be provided with endboards at opposite ends. The flooring, if any, may serve as the lower shelf.

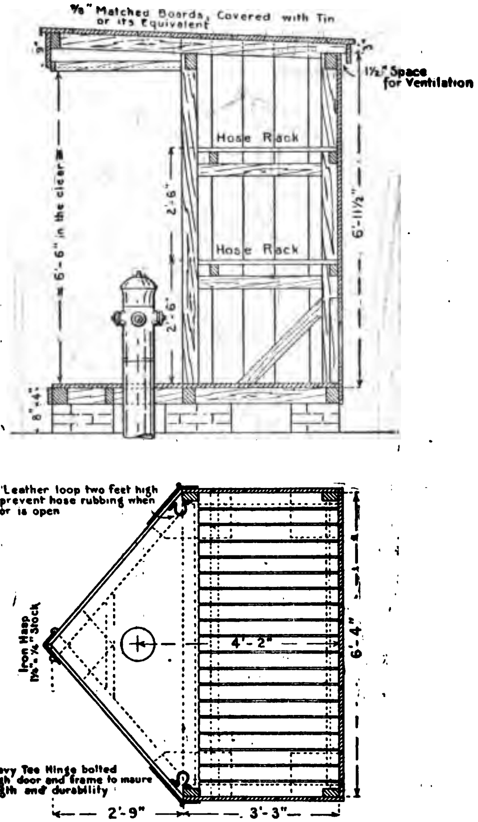

⅞" Matched Boards, Covered with Tin or its Equivalent
9"
1"
1½" Space for Ventilation
Hose Rack
Hose Rack
6'-6" in the clear
2'-6"
2'-6"
6'-11½"
8"×4"
'Leather loop two feet high to prevent hose rubbing when door is open
Iron Hasp 1⅝"×⅜" Stock
4'-2"
6'-4"
Heavy Tee Hinge bolted through door and frame to insure strength and durability
2'-9"
3'-3"

FIG. 115

NOTE.—The two lower shelves are each designed to hold 100 feet of hose attached to the hydrant on opposite sides. The upper shelf is designed to hold the spare hose.

9. FLOORS.—Where used, to be constructed of ⅞-inch stuff, not exceeding 4 inches wide and laid open.

NOTE 1.—Ordinarily no flooring is necessary, but in case the house is locked to guard against theft, a slatted floor may be used. The foundation pier and framing in front of the hydrant in Fig. 114 is unnecessary in case the house is not floored.

NOTE 2.—If necessary, the flooring may be cut away around the hydrant so as not to interfere with the swing of spanners at any outlet. See Fig. 117.

10. **VENTILATION.**—An opening permitting the free circulation of air to be provided under the eaves. The opening to be protected by a strip as illustrated in Figs. 115, 118 or 122.

11. **HARDWARE.**—a. Hinges to be extra heavy wrought tee pattern, 16 inches long. To be securely bolted through the doors and framing of the house by ⅝-inch bolts.

NOTE 1.—The hinges should be installed so as to allow the doors to swing back against the sides of the house. The bolts should be provided with washers next to the woodwork.

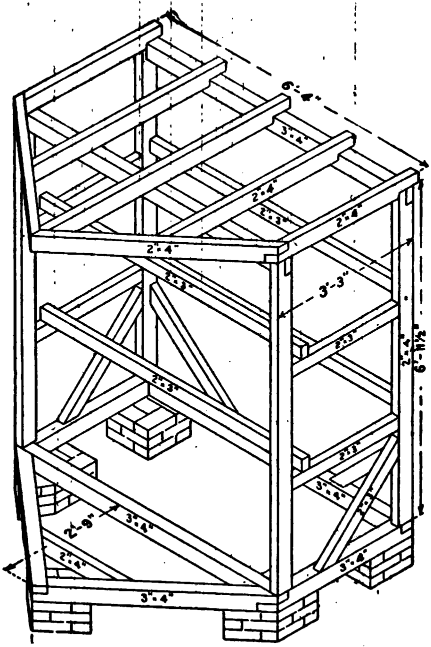


FIG. 116

NOTE 2.—The use of galvanized hardware is advised especially for the hinges.

b. Hasp. Doors on the five-sided house, shown in Fig. 115, to be provided with a hasp made of 1¼ x ¼-inch iron, bent to conform to the angle of the doors when closed. The staples at each end of the hasp to be securely bolted or clinched to the doors.

c. Latch. Doors on houses shown in Figs. 117 and 120 to be provided with a latch made of 1½ x ¼-inch iron at least 24 inches long. Latch to be loosely bolted to one door near the center, to be provided with a handle and arranged so as to drop into a catch on the opposite door. See Fig. 123. Catch to be made of 2 x ¼-inch iron bolted through the door by at least two bolts.

NOTE.—The hasp and latch specified do away with the necessity for an upright post in the center of the doorway and provide for fastening two large doors without bolting one on the inside.

d. Door Fastening. A light bar of round iron pointed and hung to bottom of door, to be provided for holding each door open. See Figs. 114 and 117.

e. Locks. Ordinarily hose houses should not be locked, but where it is necessary to guard against theft they may be locked with a specially designed lock having a substantial appearance, but which can be easily broken in case of necessity.

f. Chafing Strip. A substantial leather loop two feet high to be placed at each side of the house to protect the hose from injury by rubbing against the sharp edges at the jambs.

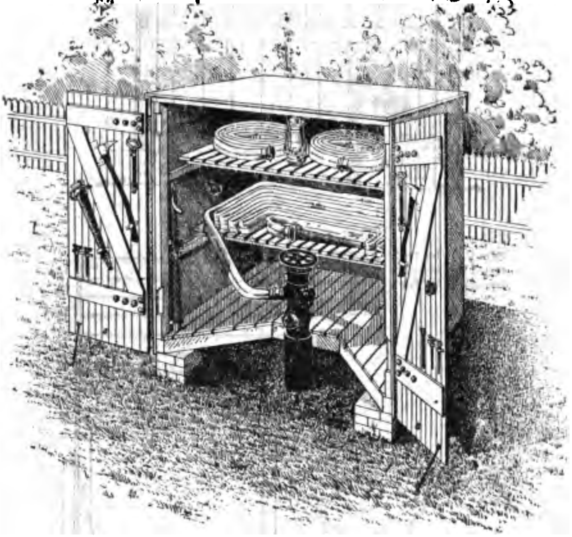


FIG. 117

NOTE 1.—The leather should be installed while the doors are against the sides of the house so as to insure unrestricted movement of the doors.

12. PAINTING.—House to be thoroughly painted on the outside with two good coats.

Equipment

13. HOSE.—a. Two or three-way hydrant houses to be supplied with 100 feet of hose, attached to the hydrant and laid in laps on the lower shelf as shown in Figs. 114 and 117. This hose to have standard play pipe attached.

NOTE.—Hose stored and attached as shown can be pulled off without twisting short at the coupling.

b. Four-way hydrant houses to be supplied with two 100-foot lengths attached on opposite sides, as shown in Fig. 120.

c. Each house to be supplied with 100 or more feet of spare hose on the upper shelf. This hose to be stored in coils of 50 feet, with the female coupling outside.

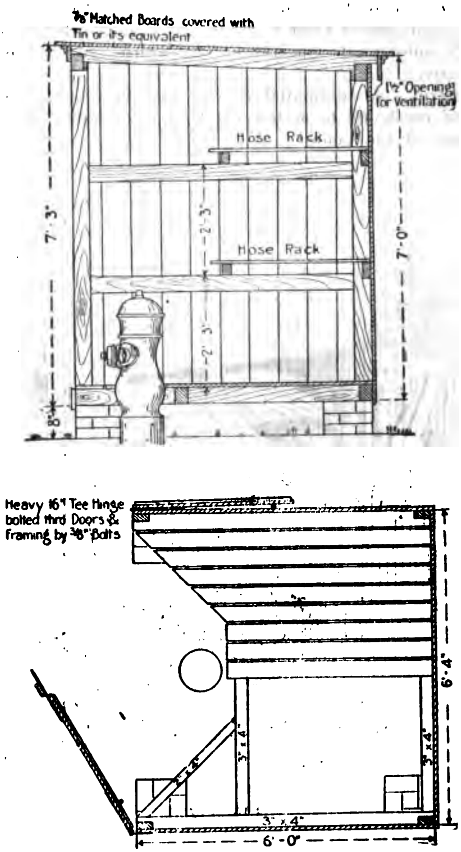

⅞" Matched Boards covered with Tin or its equivalent
1½" Opening for Ventilation
Hose Rack
Hose Rack
7'-3"
2'-3"
2'-3"
7'-0"
8"
Heavy 16" Tee Hinge bolted thro Doors & framing by ⅜" Bolts
3"x4"
3"x4"
3"x4"
6'-4"
6'-0"

FIG. 118

NOTE.—The amount of extra hose necessary depends somewhat on circumstances and may be varied by Underwriters having jurisdiction.

d. All hose to be National Standard 2⅝-inch cotton rubber-lined.

NOTE.—See list of approved hose.

14. COUPLINGS.—To be interchangeable with the public service or nearest plant from which assistance may be obtained, if there be no public service.

15. PLAY PIPES.—To be made in accordance with the National Standard specifications.

NOTE.—This specification requires a Play Pipe with swivel handles, a perfectly smooth tapering tube 30 inches long wound and painted and a 1⅛-inch smooth bore nozzle. Nozzles with larger openings should not be used except with the consent of the Underwriters having jurisdiction, and where there is ample water supply.

See specifications for Play Pipe on page 668.

16. SPANNERS.—The Tabor Spanner is recommended, as it is easily handled by an inexperienced person and will operate in either direction. See Fig. 124.

17. MISCELLANEOUS.—a. Each house to be supplied with two axes, two bars, one extra play pipe, two ladder straps, four spanners, one extra hydrant wrench and one heavy mill lantern, arranged as shown in Figs. 114, 117, or 120.

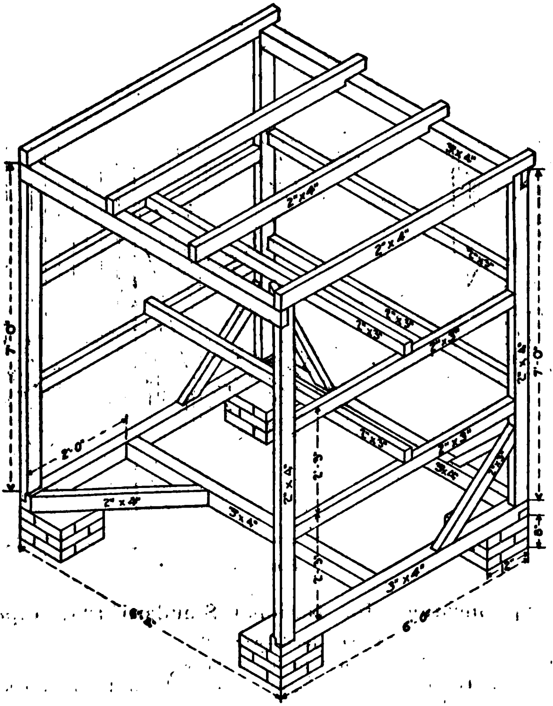


FIG. 119

b. Coils of one-half inch rope to suit the height of buildings should be hung in each house. A liberal supply of rubber hose washers should also be provided and hung in a conspicuous place.

c. Hydrant wrench to be always on the hydrant.

NOTE 1.—The equipment for the four-way house should be increased in proportion to the special demands in each case.

NOTE 2.—A substantial 12-inch hand wheel attached to the hydrant may be substituted for the hydrant wrenches otherwise required.

Rack for Washing and Drying Hose

A hose drying rack similar to that shown in Fig. 125 is recommended. This is a rack for drying hose after it has been wet either at a fire or at a test. The rack should be 52 feet long, one foot high at the lower end and at least 3 feet high at the upper end.

NOTE.—This is a simple and effective arrangement and does away with the necessity of hoisting the hose on the outside of a tower or building. The rack facilitates the proper care of the hose, which will tend to prolong its life and thus reduce the cost of the one perishable part of the equipment. The cut shows a rack in three sections, 3 to 4 feet wide, and with slatted top so that half a dozen lines of hose may be dried at one time.

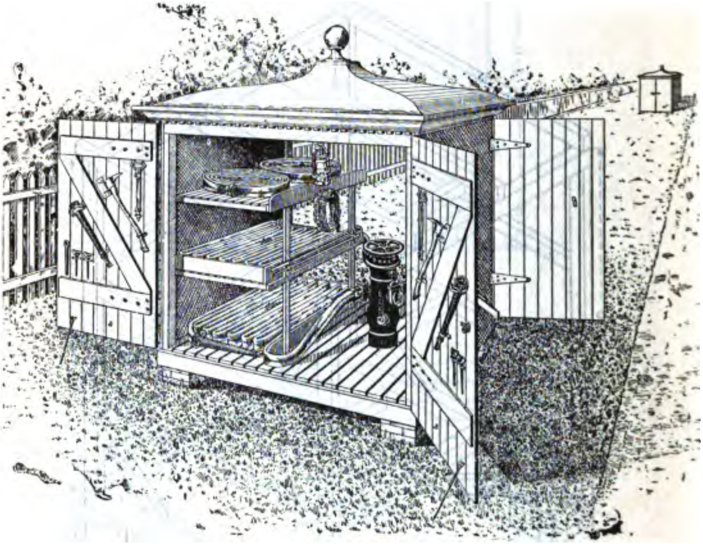


FIG. 120

Specifications for National Standard Play Pipe

1. LENGTH.—To be 30 inches long over all.

2. MOUNTINGS.—All mountings to be of brass.

3. PIPE.—a. To be of rolled brass 1/16 inch thick or seamless drawn copper 0.05 inch thick.

b. To have an inside diameter of 2 17/32 inches at the base and 1¾ inches at the throat.

c. To extend through the brass mounting at the throat.

d. Waterways to be absolutely free from rough drops of solder or other projections and to have a smooth surface throughout.

NOTE.—For best results waterway should be smooth as a gun barrel.

e. To be wound with cord and painted.

4. BUTT.—To be threaded to fit as ordered.

NOTE.—Always use City Fire Department standard thread so as to have all hose and pipes interchangeable. A recess should be provided back of the threads for retaining washer.

5. HANDLES.—To be of the swivel pattern securely attached.

6. **NOZZLE.**—a. To be 5 inches long and have an inside diameter of 1 25/32 inch at the base and 1 ⅛ inch at the discharge.

NOTE.—The nozzle is made slightly larger than the end of the pipe to prevent possibility of corner projecting against current.

b. To have a straight taper finished off at discharge with an easy curve.

c. The tip of the nozzle to be extra heavy and cut out at the discharge orifice to prevent bruising.

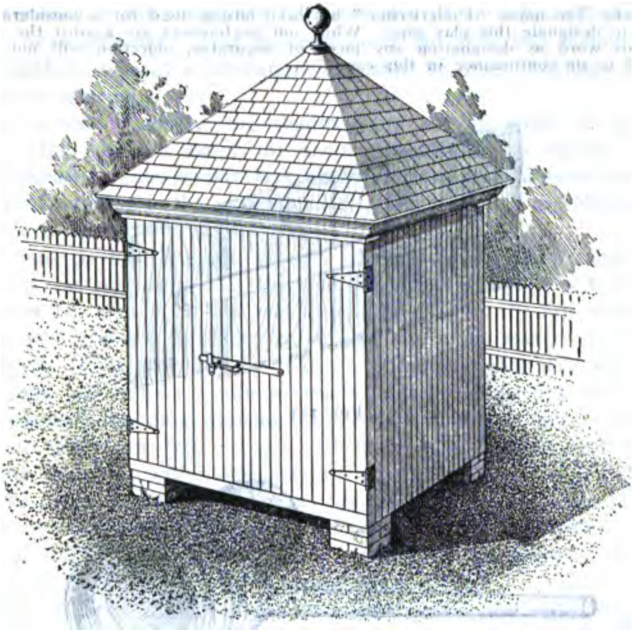


FIG. 121

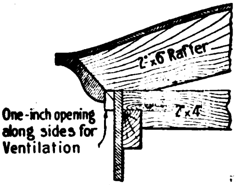


FIG. 122

d. Inside of the discharge orifice to be straight for ¾ inch.

e. The brass mounting to which the nozzle is screwed to be provided with an outside groove for retaining the washer, to be 2 5/16 inch diameter outside the threads and threaded with the Providence thread (12 to the inch).

NOTE.—The washer is placed outside to prevent it from projecting inside the pipe and disturbing the stream. A projecting lip covering the edge of the washer prevents its being blown out by the pressure.

7. **WORKMANSHIP.**—All parts to be made, fitted and finished in a first-class workmanlike manner throughout.

8. **MARKING.**—The maker's name and the year of manufacture to be stamped on the butt and the words "National Standard" stenciled on the cord winding.

NOTE.—The name "Underwriter" has been largely used for a considerable time to designate this play pipe. While our preferences are against the use of this word as designating any piece of apparatus, objection will not be raised to its continuance in this case.

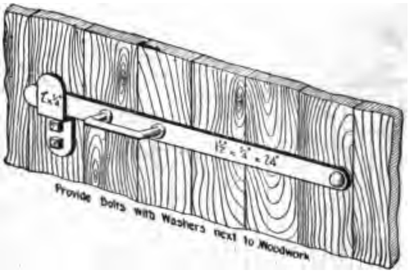


FIG. 123

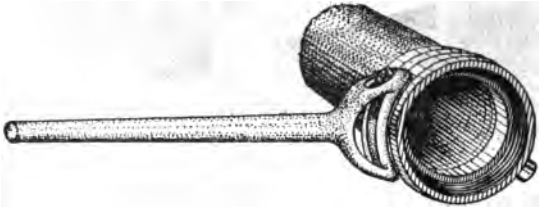


FIG. 124

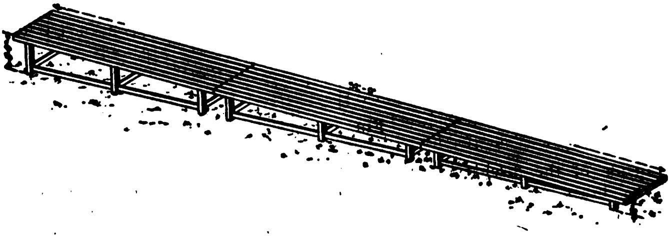


FIG. 125

WATER SUPPLY FOR FIRE PROTECTION

Quantity Required.—No definite statement can be given as to the amount of water required for protection of an industrial plant, store or warehouse. This depends upon the area and height of the building, type of construction, exposure by other buildings and class of occupancy.

For sprinkler supply, the requirements are as given on page 564. This means a supply of about 2,000 gallons a minute for a building of 25,000 square feet, the maximum area allowed for a fireproof building in the recommended building code of the National Board of Fire Underwriters.

For use as hose lines, it is even harder to fix upon a required quantity, as not only does the question of how much is needed enter in, but also as to how much could be used by the fire fighting force which would be called in in case the plant was completely involved. It is safe to say that the minimum should never be less than 500 gallons a minute available for at least 3 hours for any plant or building desiring protection from hose lines. It is safe to assume a flow of 500 gallons from a hydrant and that all the hydrants within 500 feet of any one part of a building will be in use at time of a serious fire, and for the extensive plant or a group of individual factories, all the hydrants within 500 feet of the largest building may be in use, giving a possible maximum required fire draft of 5,000 to 10,000 gallons a minute.

Flow Tests.—In all cases there should be absolute assurance of a good water supply for fire protection; it should be the aim of the owner or his engineer to see that the public water supply, if one is available, is at sufficient pressure and can maintain an adequate pressure during the maximum draft that the system may be called upon to deliver. If dependence is placed entirely or partly upon a private system, the same consideration must be given. It is possible in some cases for an engineer to calculate sufficiently close to give this assurance of adequacy of water supply, and in the past it has often been assumed that if pressure were sufficiently high and the main in the street was of good diameter, even calculation would not be necessary. Such assumptions should no longer be depended upon; simple methods of making tests are applicable and are used by insurance inspectors to great advantage. These should be adopted and used by the owners of valuable property to a greater extent and by water works and insurance engineers whose duty it is to see that a good water supply is provided.

It is not feasible to open up enough sprinkler heads to demonstrate whether the supply is ample, and it results in a large amount of hose being used if a duplication of possible fire conditions is attempted. Equally as good results can be obtained by measuring the flow from open hydrant outlets and simultaneously observing the drop in pressure on the system. Test should be made at least yearly, as it is only by comparative tests that the effect of age on a water works system can be kept track of. Also such tests often show that some important gate valve has been left closed.

FIRE FLOW TESTS AS MADE BY THE COMMITTEE ON FIRE PREVENTION OF THE NATIONAL BOARD OF FIRE UNDERWRITERS

Method.—The method of conducting "Fire Flow Tests" as practised by the engineers of the Committee on Fire Prevention of the National Board of Fire Underwriters is a development of the scheme of measuring discharges from smooth-bore fire department nozzles by means of the Pitot tube and gage, originated by Mr. John R. Freeman and now used by the National Board in its tests of fire engines.

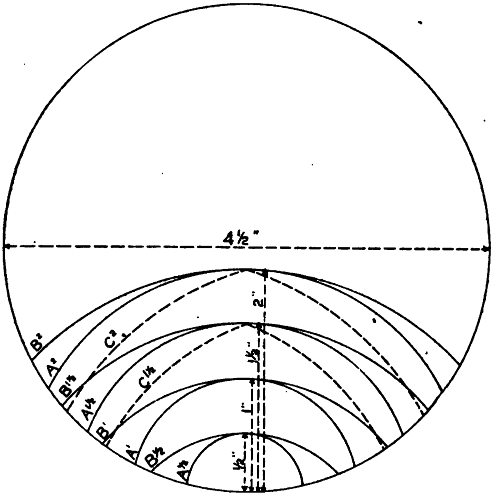
Discharges directly from the open butts of hydrants are subject to less accurate measurement than those from smooth-bore nozzles; the orifice is often not completely filled, especially in the case of steamer outlets (4- or 4½-inch), and the velocity of discharge is not uniform throughout the part that is filled; neither of these features is so marked in the 2½-inch outlets as in the steamer outlets.

Hydrant Discharges.—It is possible to measure hydrant discharges with considerable accuracy by the use of short lines of hose and large nozzles; however, in cities where the normal hydrant pressures are low, only a small part of the total quantity available for engine supply may be obtained in this way, and much more time and labor is consumed than when open butt discharges are measured. For these reasons, and in order that a representative number of tests might be made in a reasonable time in the various cities reported on by the National Board, the present scheme was worked out. It is believed that the results obtained will show not more than 5 per cent of error.

The number of hydrants in a group, all of which are opened simultaneously, varies from 2 to 6, or even more in exceptional cases, depending upon the quantity of water available, the pressures and the character of the district in which the test is made. It is usual to open all available outlets on the hydrants used; however, if the pressures are high enough to furnish effective streams direct from hydrants, it is better to open only enough outlets to lower the pressure in the mains to a figure assumed to be the minimum consistent with good fire service, which will range from 60 to 75 pounds or more, depending upon the character of the district. Diameters of outlets are recorded to the nearest sixteenth of an inch.

Pressure Gaged.—The pressure in the mains before and during the tests is determined by attaching a gage to a hydrant preferably located near the center of the group to be tested; it is sometimes advisable to have another gage at a hydrant outside the group, to determine the loss of head in the main arteries, or a recording gage located near the center of the distribution system may serve the purpose for a number of groups. Know-

DIAGRAM
SHOWING
REDUCTION OF AREA OF FREE DISCHARGE
FROM
STEAMER OUTLET OF HYDRANT
TO BE USED IN PITOT MEASUREMENT



Area of 4½ inch Outlet = 15.90

Flowing full with Uniform Velocity Gives 100% of Table Figures
" " minus $A^{\frac{1}{2}}$ = 15.42 ÷ 15.90 = 97% or 31/32 of Table Figures
" " " A^1 = 14.36 ÷ 15.90 = 90% " 9/10 " " "
" " " $A^{1\frac{1}{2}}$ = 12.76 ÷ 15.90 = 80% " 4/5 " " "
" " " A^2 = 10.69 ÷ 15.90 = 67% " 2/3 " " "
" " " $B^{\frac{1}{2}}$ = 15.26 ÷ 15.90 = 96% " 31/32 " " "
" " " B^1 = 14.02 ÷ 15.90 = 88% " 7/8 " " "
" " " $B^{1\frac{1}{2}}$ = 12.28 ÷ 15.90 = 77% " 3/4 " " "
" " " B^2 = 10.19 ÷ 15.90 = 66% " 5/8 " " "
" " " $C^{1\frac{1}{2}}$ = 13.44 ÷ 15.90 = 85% " 5/6 " " "
" " " C^2 = 11.66 ÷ 15.90 = 73% " 3/4 " " "

SUMMARY

Hole ½" High, Deduct 1/32 from Discharge in Table
" 1" " " 1/10 to 1/8 " " " "
" 1½" " " 1/6 to 1/4 " " " "
" 2" " " 1/4 to 1/3 " " " "

FIG. 126

DISCHARGE THROUGH CIRCULAR OUTLETS IN GALLONS PER

Coefficient .90

Pressure	2¼"	2 5/16"	2⅜"	2 7/16"	2½"	2 9/16"	2⅝"	2 11/16"	3¾"	3 13/16"	3⅞"	3 15/16"
½	90	100	110	110	120	120	130	140	270	280	290	300
1	140	140	150	160	170	180	180	190	380	390	400	420
1½	170	180	190	200	210	220	230	240	460	480	490	510
2	190	200	210	230	240	250	260	270	530	550	570	590
2½	220	230	240	250	270	280	290	310	600	620	640	660
3	240	250	260	280	290	310	320	340	660	680	700	720
3½	250	270	280	300	310	330	350	360	710	730	760	780
4	270	290	300	320	340	350	370	390	760	780	810	830
4½	290	300	320	340	360	370	390	410	800	830	860	890
5	300	320	340	360	380	390	410	430	850	880	900	930
5½	320	340	350	370	390	410	430	450	890	920	950	980
6	330	350	370	390	410	430	450	470	930	960	990	1020
6½	350	370	390	410	430	450	470	490	960	1000	1030	1060
7	360	380	400	420	440	470	490	510	1000	1030	1070	1100
7½	370	390	410	440	460	480	510	530	1040	1070	1110	1140
8	380	410	430	450	480	500	520	550	1070	1110	1140	1180
8½	400	420	440	460	490	510	640	560	1100	1140	1180	1220
9	410	430	450	480	500	530	550	580	1130	1170	1210	1250
9½	420	440	470	490	520	540	570	600	1170	1210	1240	1280
10	430	450	480	500	530	560	580	610	1200	1240	1280	1320
10½	440	470	490	520	540	570	600	630	1230	1270	1310	1350
11	450	480	500	530	560	590	610	640	1250	1300	1340	1380
11½	460	490	510	540	570	600	630	660	1280	1330	1370	1410
12	470	500	520	550	580	610	640	670	1310	1350	1400	1440
12½	480	510	540	560	590	620	650	690	1340	1380	1430	1470
13	490	520	550	570	610	640	670	700	1360	1410	1460	1500
13½	500	530	560	590	620	650	680	710	1390	1440	1480	1530
14	510	540	570	600	630	660	690	730	1420	1460	1510	1560
14½	520	550	580	610	640	670	700	740	1440	1490	1540	1590
15	530	560	590	620	650	680	720	750	1470	1510	1560	1610
15½	540	570	600	630	660	700	730	760	1490	1540	1590	1640
16	540	570	610	640	670	710	740	780	1510	1560	1610	1670
16½	550	580	620	650	680	720	750	790	1540	1590	1640	1690
17	560	590	620	660	690	730	760	800	1560	1610	1660	1720
17½	570	600	630	670	700	740	770	810	1580	1640	1690	1740
18	580	610	640	680	710	750	780	820	1600	1660	1710	1770
18½	590	620	650	690	720	760	790	820	1630	1680	1740	1790
19	590	630	660	700	730	770	810	840	1650	1700	1760	1820
19½	600	640	670	700	740	780	820	860	1670	1730	1780	1840
20	610	640	680	710	750	790	830	870	1690	1750	1810	1860
21	620	660	690	730	770	810	850	880	1730	1790	1850	1910
22	640	670	710	750	790	830	870	910	1770	1830	1890	1960
23	650	690	730	760	810	850	890	930	1810	1880	1940	2000
24	670	700	740	780	820	860	910	950	1850	1920	1980	2040
25	680	720	760	800	840	880	920	970	1890	1950	2020	2080
26	690	730	770	810	860	900	940	990	1930	1990	2060	2130
27	710	750	790	830	870	920	960	1010	1970	2030	2100	2170
28	720	760	800	840	890	930	970	1020	2000	2070	2140	2210
29	730	770	820	860	310	950	990	1040	2040	2110	2170	2240
30	750	790	830	870	920	970	1010	1060	2070	2140	2210	2280
31	760	800	840	890	940	980	1030	1080	2110	2180	2250	2320
32	770	810	860	900	950	1000	1040	1100	2140	2210	2280	2360
33	780	830	870	920	970	1010	1060	1110	2170	2250	2320	2390
34	790	840	880	930	980	1030	1070	1130	2210	2280	2350	2430
35	810	850	900	940	990	1040	1090	1140	2220	2310	2390	2470
36	820	860	910	960	1010	1060	1110	1160	2270	2340	2420	2500

MINUTE FOR INDICATED VELOCITY PRESSURE IN POUNDS

4"	4 1/16"	4⅛"	4 3/16"	4¼"	4 5/16"	4⅜"	4 7/16"	4½"	4 9/16"	4⅝"	4 11/16"	Pressure
300	310	320	330	340	350	370	380	390	400	410	420	½
430	440	460	470	490	500	520	530	550	560	570	590	1
530	540	560	580	600	610	630	650	670	690	700	720	1½
610	630	650	670	690	710	730	750	770	790	810	840	2
680	700	720	750	770	790	820	840	860	890	910	940	2½
750	770	790	820	840	870	900	920	940	970	1000	1020	3
810	830	860	880	910	940	970	990	1020	1053	1070	1100	3½
860	890	920	950	970	1000	1030	1860	1090	1120	1150	1180	4
910	940	970	1000	1030	1060	1090	1120	1160	1190	1220	1250	4½
960	990	1020	1060	1090	1120	1150	1190	1220	1250	1280	1320	5
1010	1040	1070	1110	1140	1180	1210	1240	1280	1310	1350	1390	5½
1050	1090	1120	1160	1190	1230	1260	1300	1330	1370	1410	1450	6
1100	1130	1170	1200	1240	1280	1310	1350	1390	1430	1470	1510	6½
1140	1170	1210	1250	1290	1330	1360	1400	1440	1480	1520	1560	7
1180	1210	1250	1290	1330	1370	1410	1450	1490	1530	1570	1620	7½
1210	1250	1290	1340	1380	1420	1460	1500	1540	1580	1620	1670	8
1250	1290	1330	1380	1420	1460	1500	1540	1590	1630	1680	1720	8½
1290	1330	1370	1420	1460	1500	1540	1590	1630	1680	1720	1770	9
1320	1370	1410	1460	1500	1540	1590	1630	1680	1720	1770	1820	9½
1360	1400	1450	1490	1540	1580	1630	1670	1720	1770	1820	1870	10
1390	1440	1480	1530	1580	1620	1670	1720	1760	1810	1860	1910	10½
1430	1470	1520	1570	1610	1660	1710	1760	1810	1860	1910	1960	11
1460	1500	1550	1600	1650	1700	1750	1800	1850	1900	1950	2000	11½
1490	1540	1580	1640	1690	1730	1780	1840	1890	1940	1990	2050	12
1520	1570	1620	1670	1720	1770	1820	1870	1930	1980	2030	2090	12½
1550	1600	1650	1700	1750	1800	1860	1910	1970	2020	2070	2130	13
1580	1630	1680	1730	1790	1840	1880	1950	2000	2060	2110	2170	13½
1610	1660	1710	1770	1820	1870	1930	1980	2040	2090	2150	2210	14
1640	1690	1740	1800	1850	1910	1960	2020	2080	2130	2190	2250	14½
1660	1720	1770	1830	1880	1940	1990	2050	2110	2170	2230	2290	15
1690	1750	1800	1860	1920	1970	2030	2090	2150	2200	2260	2330	15½
1720	1770	1830	1890	1950	2000	2060	2120	2180	2240	2300	2360	16
1750	1800	1860	1920	1980	2030	2090	2150	2210	2270	2330	2400	16½
1770	1830	1890	1950	2010	2060	2120	2180	2250	2310	2370	2440	17
1800	1850	1910	1980	2040	2090	2160	2220	2280	2340	2400	2470	17½
1840	1880	1940	2000	2060	2130	2180	2250	2310	2370	2440	2510	18
1850	1910	1970	2030	2090	2150	2220	2280	2350	2410	2470	2540	18½
1870	1930	1990	2060	2120	2180	2250	2310	2380	2440	2510	2580	19
1900	1960	2020	2090	2150	2210	2280	2340	2410	2470	2540	2610	19½
1920	1980	2050	2110	2180	2240	2300	2370	2440	2500	2570	2640	20
1970	2030	2100	2160	2230	2290	2360	2430	2500	2560	2630	2710	21
2020	2080	2150	2220	2290	2350	2420	2490	2560	2620	2700	2770	22
2060	2120	2190	2270	2340	2400	2470	2540	2610	2690	2760	2820	23
2110	2170	2240	2310	2380	2460	2520	2600	2670	2740	2820	2900	24
2150	2220	2280	2360	2430	2510	2580	2650	2720	2800	2870	2960	25
2190	2260	2330	2410	2480	2550	2630	2700	2780	2850	2930	3020	26
2230	2300	2380	2450	2530	2600	2680	2760	2830	2910	2990	3070	27
2280	2350	2420	2500	2580	2650	2730	2800	2880	2960	3040	3130	28
2320	2390	2460	2540	2620	2700	2770	2850	2940	3020	3090	3180	29
2380	2430	2510	2590	2670	2740	2820	2900	2990	3070	3150	3240	30
2390	2470	2550	2630	2710	2790	2870	2950	3030	3120	3200	3290	31
2430	2500	2590	2670	2750	2830	2920	3000	3080	3170	3250	3340	32
2470	2550	2630	2720	2800	2880	2960	3040	3130	3220	3300	3390	33
2510	2580	2670	2760	2840	2920	3000	3090	3190	3260	3350	3440	34
2540	2620	2710	2800	2880	2960	3050	3140	3210	3310	3400	3500	35
2590	2660	2740	2830	2920	3000	3090	3180	3270	3360	3450	3540	36

ing the loss of head due to ordinary consumption, and the additional loss due to the measured flow from hydrants, a close approximation may be made of the quantity available at any given pressure.

AREA OF "NO FLOW."—It has already been noted that hydrant outlets, especially the large ones, are not completely filled by the stream; the area of no flow is almost always a segment in the bottom of the outlet, of varying height depending upon the design of the hydrant and somewhat upon the velocity of the stream. Any projection into the waterway, such as the end of the stem of an independent valve or a roughness of the nipple, will also produce small "holes" in the stream. The area of no flow is in most cases fairly well defined, and the shape of the "hole" is sufficiently uniform to enable its proportion to the total area to be determined by measuring its height with a rule; for instance, with a 4½-inch outlet, a "hole" 1 inch high forms 10 to 12 per cent of the area of the outlet, a 1½-inch hole 20 to 25 per cent, and so on. The correction to be made may be determined by referring to Figure 126.

VELOCITY.—In determining the average velocity of the stream issuing from the outlet, the Pitot tube is moved throughout the area, and the observer will soon train himself by this traverse to fix upon a substantially accurate average; readings noted at the center and near the ends of the horizontal and vertical diameters will usually suffice, and the center reading in a small outlet is in most cases very near the average for the whole area. Readings should not be taken closer than ¼-inch to the sides of the orifice, since there is a noticeable retardation of velocity caused by friction against the walls of the hydrant nipple. This retardation necessitates applying a coefficient of discharge, which has been determined by experiment on three different makes of hydrants, with outlets of various sizes and with velocities of discharge ranging from ½ to 28 pounds; the discharges as measured by the Pitot tube were compared with those determined variously by Venturi-meter, Pitometer in supply main, and by a Worthington current meter. The coefficient of discharge ranged from 0.85 to 0.96, with an average of 0.91. It is therefore concluded that a coefficient of 0.90 is a fair one to use; this is to be applied after allowance has been made, as above noted in the case of outlets not completely filled by the stream. From the tables on pages 674 and 675 results can be readily figured, or for any other size of outlet, a discharge can be obtained as given in the formula on page 699.

The Pitot tube used in determining discharges from hydrant outlets has a straight blade about 4 inches long, which is threaded into one end of a piece of ¼-inch brass pipe 8 or 10 inches long, on the other end of which is screwed the gage by which the velocity of discharge is determined; a union may be used to keep the joints tight in whatever position the gage may be.

GAGE USED.—The gage which appears to be best suited for this work is 3-inch, graduated in half pounds, from 0 to 50 pounds. Such a gage may be read easily to the nearest quarter pound; corrections should be made as indicated by calibrations before and after using; either by means of a weight tester or by comparison with an accurate test gage.

Velocity heads of 1 pound or more are desirable, since they are read with greater accuracy by the ordinary observer, and also because any inaccuracy in the gage reading has less effect on the correctness of the discharge figures. However, discharges may be determined with considerable accuracy in cases where the velocity head is as low as ¼ pound. It is better where discharges are small to use only one small outlet, rather than two small ones or a large one.

FIRE ENGINE TESTS AND FIRE STREAM TABLES*

The National Board of Fire Underwriters issued a pamphlet in 1910 on "Fire Engine Tests and Fire Stream Tables," which is reprinted in this and following pages by permission of the National Board of Fire Underwriters.

PREFACE

This pamphlet has been prepared for the purpose of assisting fire department officials and others who may wish to determine the condition of fire engines. It may also be of service in testing the capacity of new engines with a view to their acceptance by a city.

Tests similar to those outlined herein have been adopted by many fire departments and are being made by our engineers in their investigation of cities throughout the country, so that by corresponding with this Board, the location of the nearest field party may be ascertained and if desired, an opportunity afforded to observe such tests.

The appended fire stream tables, on pages 702 to 723, are based on tests of rubber-lined fire hose made in October, 1909, by our engineers, with the assistance of the New York Fire Department and the co-operation of the Department of Water Supply of New York City. These tables may also be used to find the approximate amount of water used at a fire, if engineers will observe from time to time the water pressure carried and the length of time at work. With an approximate average of the water pressure at each engine, the amount of water delivered per minute can be found for each line if the size of nozzle and length of hose is also known. Copies of this pamphlet will be sent to such captains of companies and engineers of steamers as would use them in keeping accurate records of the performance of their engine at fires.

NATIONAL BOARD OF FIRE UNDERWRITERS.
COMMITTEE ON FIRE PREVENTION,
76 William Street,
August, 1915. New York.

PRACTICAL TESTS FOR FIRE ENGINES

It is the purpose of this manual to set forth convenient and practical methods of making fire engine tests which will show the physical condition of engines, their capacity for delivering water at a reasonable pressure and the ability of the operating crews. The method described has been in use for a number of years and has been found practical, exact and of great value. Although methods similar to that described below are in use in some departments, the character of tests made in many cities, and especially those for acceptance, are usually more spectacular than exact. The throwing of a stream over a church spire, city hall or court house does not necessarily show that the engine is capable of delivering its full rated capacity at a proper working pressure.

Investigation has shown that where regular and systematic tests of engines are not made, even in well managed fire departments, defects often exist

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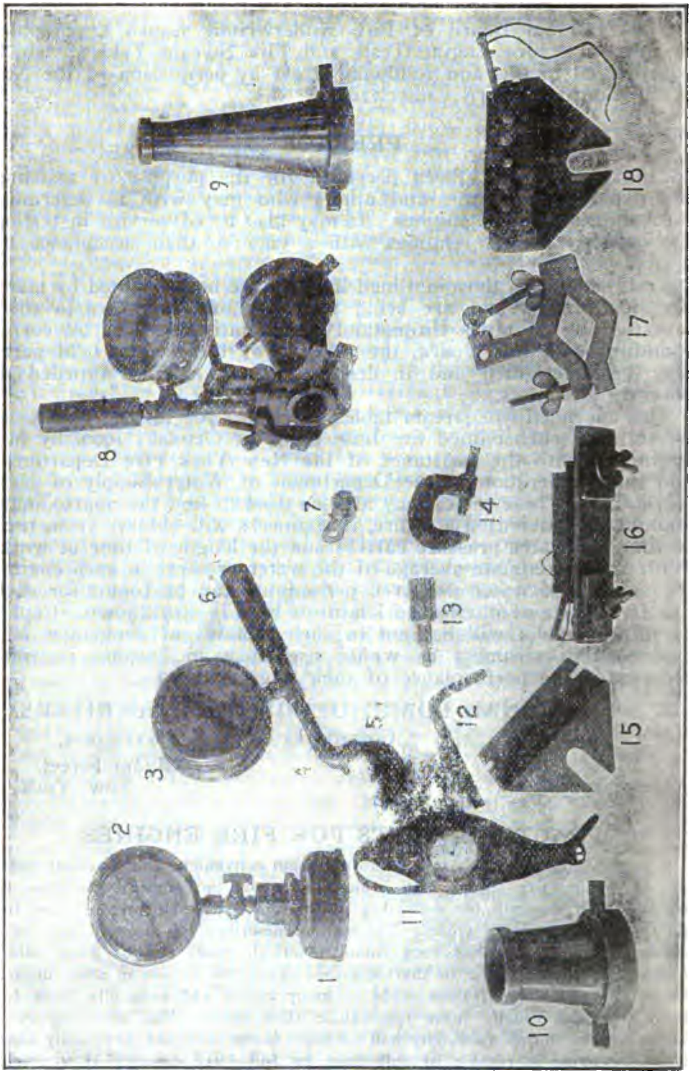


Plate I.—Apparatus for Testing Fire Engines

which may continue unsuspected for considerable periods and become manifest under the stress of a large fire, where the engine is called upon to deliver its full capacity under suitable working pressures. Furthermore, regular tests are a most valuable drill for engine crews, for in only a few departments do they receive sufficient training in operating engines to capacity. The breakdown of an engine at a fire or the inability of the crew to operate it to capacity may be the direct cause of confusion and the needless loss of property and perhaps of life, to the discredit of the department.

Contracts for new fire engines usually contain guarantees that the engine will deliver a certain quantity of water, but often do not specify the pressure at which it is to be delivered, nor provide for any definite tests which will accurately determine whether the engine has fulfilled the guarantee; or, in other words, if the department is getting what it is paying for. In several cities, engines are required to fill large measured tanks in a specified time, but this is a cumbersome metbod at best, and such tanks are frequently unavailable; this usually gives no definite results as to pressure obtained and power developed.

STEAM FIRE ENGINES

WHAT TEST SHOULD SHOW.—A practical test should show, with fair accuracy, the condition of both water and steam ends of pumps and the condition of the boiler; determine the amount of water which the engine will pump at a reasonable working pressure, such as would be required when operating at a large fire; demonstrate the ability of the engine to draft water, whether the pumps and waterways are tight under high pressures and steam valves are properly set, and whether the coal used is quick steaming and free from objectionable impurities. In addition, the test should be of such a character as to approach the working condition at a serious fire where the full capacity of the engine would be required, and at the same time be easily understood. The following tests are intended to bring out all of these points.

DISPLACEMENT TEST.—The displacement test indicates very closely the actual condition of the pumps as a whole and, in conjunction with the high pressure and valve tests, the condition of the plungers, pump valves, packing, etc. The high pressure test, in connection with the results obtained from the capacity test, indicates the setting of steam valves and condition of steam cylinders and packed joints. The capacity test shows the steaming quality of the boiler under heavy draft and the ability of the engine to make sufficient speed to develop its capacity when working against a reasonable water pressure. If the test is made from a cistern or reservoir, it will show the ability of the engine to draft; if made from a hydrant, the percentage of slip obtained will indicate this feature, as an engine showing less than 7 per cent slip may be depended upon to take suction satisfactorily. Incidentally, the test also shows the ability of the engine crew in operating and stoking the engine.

Any machine, when new, should be capable of greater work than after several years of service; for this reason, a new engine should be given an acceptance test at least as severe as any work it may have to perform in actual service. This test should bring out not only the capacity to pump the actual volume of water specified by the maker as the rated capacity, but also to do this at a good working pressure.

A good specification, applying equally well to steam fire engines and automobile fire engines, is that the engine should deliver its full rated capacity at 120 pounds net pressure and 50 per cent. of its rated capacity at 200 pounds net pressure. This will assure sufficient boiler capacity in steam fire engines and motors of high enough power in automobile fire engines.

Engines in service need not be given as severe a test as those being accepted, as it is mainly their general condition that is to be ascertained; for this reason, 100 pounds net water pressure would seem a sufficiently high requirement for the ordinary capacity test, which should be made at least yearly.

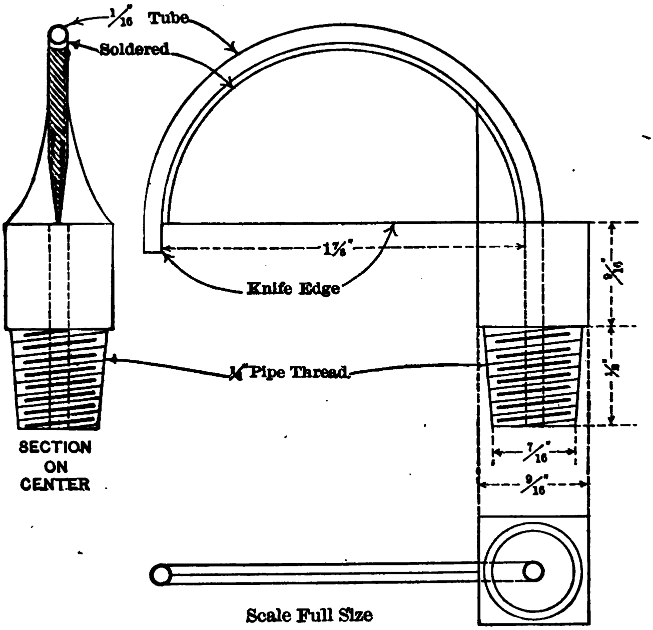
Apparatus Necessary for Testing.—For the tests outlined below, no elaborate or costly outfit is needed, the only special appliances absolutely required being as shown on Plate I and listed below:

A revolution or speed counter (Figures 7, 13 and 18).
A stop-watch and wrist strap (Figure 11).
A small Pitot tube (Figure 5).
An air chamber on Pitot (Figure 6).
Two or more pressure gages (Figures 2 and 3).
A set of smooth bore nozzles (Figures 9 and 10).
A hydrant or engine discharge cap (Figure 1).
Appliances for attaching counter (Figures 14 and 15 or Figure 16).

For convenience, it is desirable to have a Pitot bracket (Figure 17).

This is shown attached in Figure 8, with a special form of elbow (Figure 4) and ¼-inch bent rod (Figure 12).

NOZZLE STREAM PITOT



Scale Full Size
To be of brass and finished smooth

The revolution counter should be of a type easily attached to the engine frame, or any convenient part, and so made as to register accurately at any speed likely to be reached by a reciprocating engine and be easily read.

The counter may be provided with straps for attaching to engine, or with the clamp and angle iron shown on Plate I, Figures 14 and 15, and Plate II, or with bolts and slotted lugs as shown in Plate I, Figure 16.

For high speeds, and particularly where the speed is uniform, as with motor driven pumps, the speed counted, Figure 13, is best; 30 second or 1 minute readings can be taken from some shaft at frequent intervals.

Most Tachometers and speed indicators are unsuitable for steam fire engine work, as the vibration is apt to render their readings unreliable, and the variation in speed makes their readings of little value.

A stop-watch can be purchased for less than $10, although an ordinary watch can be used.

The Pitot tube may be any of several suitable types now on the market, or may be readily constructed; dimensions are given below. It should be connected by ¼-inch brass pipe fittings to a pressure gage; to prevent vibration of the needle, an air chamber should be provided as shown in Plate I.

The pressure gages should be preferably not more than 3½ inches in diameter, in order that they may be conveniently handled. They should be without a rest pin for the needle, in order that any disarrangement of the needle may be readily observed; one capable of indicating a vacuum should be provided if a gage is used on the suction; the Pitot gage should read up to 200 pounds, and be divided preferably for every pound and marked every 5 or 10 pounds; the pressure gage should read up to 300 pounds, and where tests to 250 pounds are made, to 400 pounds, and may be divided only for every 5 pounds. Gages, especially those used with the Pitot, should be of good quality and accurate. They should be carefully calibrated (tested) with a weight tester or a standard gage before each day's work.

NOZZLES.—Nozzles suitable for testing are usually found in the regular equipment of every fire department. Only smooth bore tapered nozzles should be used, as discharges from ring nozzles are uncertain. Care should be taken that the tips are not nicked or otherwise injured, and that washers do not project into the pipe, as a perfectly smooth waterway is essential. The ring nozzles on many engines have loose rings, which may be slipped out by unscrewing the end cap, leaving a suitable smooth-bore tip. Shut-off nozzles should not be used, as these generally have interior projections or breaks in the waterway, likely to cause eddies in the stream. Where much testing is to be done, it is better to set aside nozzles, keeping them solely for that purpose. The bore of nozzles should be accurate to size within 1/1,000 of an inch and carefully measured.

CHECKING ENGINE GAGE.—The engine-discharge cap, or hydrant cap (in most cities these have the same thread) is tapped for ¼-inch pipe thread and fitted with a nipple and stop-cock for attaching the test gage. By attaching to the discharge outlet of the engine as shown on Plate II, the engine water gage and the test gage may be compared to determine if the engine gage is correct. Where there is time to detach the water gage and a testing set is available, the gage can be more accurately checked. The steam gages are less likely to get out of order, being less subject to sudden fluctuations, and a comparison of readings of side and rear steam gages will usually be sufficient. If the engine has no suction gage or tapped suction cap, the engine or hydrant cap should be used on the second outlet of the hydrant when testing an engine at a double outlet hydrant.

PERSONNEL.—Tests are best made by a supervisor (as the master mechanic or other officer conducting the test will hereafter be called), with an assistant accustomed to reading gages. Tables showing the discharge at various pressures through different nozzles, for use with Pitot tube readings, are to be found on pages 704 and 705. A suitable form for recording data of

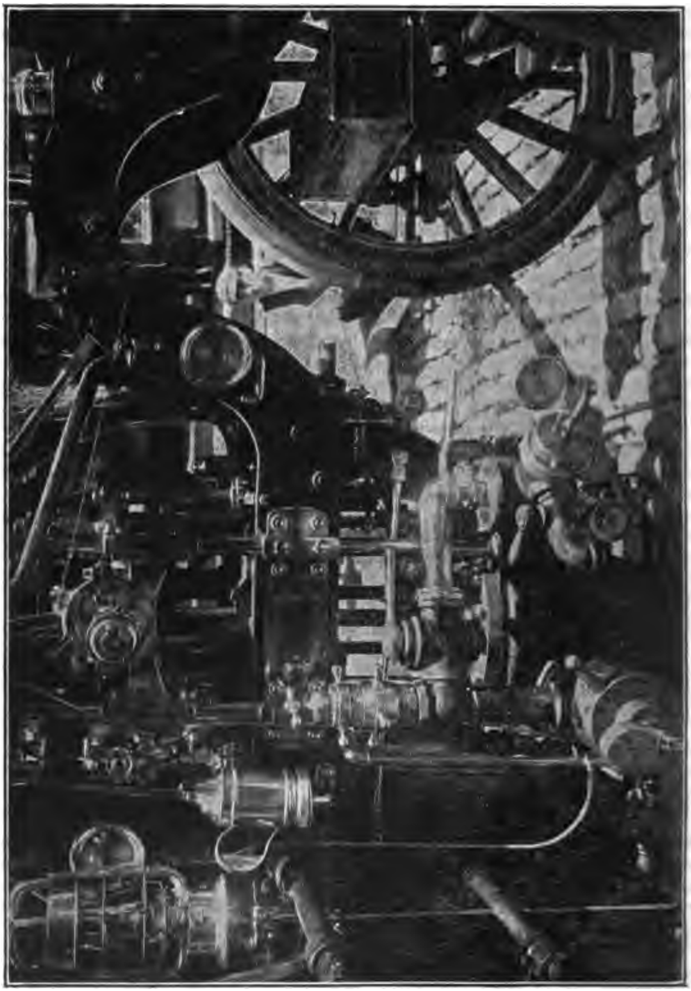


PLATE II.—Method of Attaching Gages and Counter for Testing Engines

tests is shown on page 686, and until the supervisor becomes familiar with tests, it is advisable to use a similar form at the tests in order not to overlook any necessary data. Later, a pocket note-book will doubtless be found more convenient, care being taken to record all the necessary data.

PRELIMINARY TO TEST.—If possible, calibrate gages of engine before the test, by detaching and comparing on a portable gage-testing set. They should be calibrated in the position in which they are to be used, either horizontally or vertically. If this is not done, check water and suction gages at test, as explained below.

If it is desired to determine the ability of the regular engine crew, the engine should, of course, be operated by them; if the condition and capacity of the engine are the unknown factors, a crew known to be efficient should be selected.

If there is any convenient body of water, or cistern, where water may be drafted with at least 10 feet of lift, then test should be made at draft; otherwise, attach engine to hydrant, care being taken to get a hydrant attached to a large main (8-inch or larger), and that the hydrant pressure is not excessive, preferably below 40 pounds. Four-inch or larger suction should be used. After suitably stationing engine, light the fire; note the time when smoke comes from stack, when steam gage needle moves, at 50 pounds of steam, at 100 pounds, and pressure and time of blowing off. If engine has hot water in boiler, this may be omitted, noting only the pressure at which safety valve blows off. Then, if water gage on engine has not been calibrated (checked), attach hydrant cap and 200-pound test gage to engine discharge outlet. Record zero of all three gages—water, suction and test gages; open hydrant and record static pressure on all three gages; then with churn (hand relief) valve partly open and discharge gates shut, pump up pressure and compare test and water gages at 80 pounds, 100, 110, 120, etc., up to 120 pounds over the static or hydrant pressure. If engine has no suction gage, one of the suction caps on the engine can be tipped to connect the gage or the engine or hydrant cap provided with the second gage should be attached to one hydrant outlet.

Let supervisor and assistant compare watches and set second hands together, or nearly so; this is more quickly accomplished if one watch has a stop-hand. The supervisor will find it convenient to tie his watch to coat or wrist in order to leave his hands free to hold note-book or Pitot. A leather watch holder and wrist strap, as shown on Plate I, such as any harness maker can make, is a convenient appliance for this purpose. Attach the revolution counter and connect with one of the eccentric strap oil cups or studs by a short length of cord, have engine started slowly and adjust counter cord so that each revolution registers.

DISPLACEMENT AND CAPACITY TEST.—While the engine is getting up steam, have firemen lay hose and connect nozzle. If testing on a paved street, it is best to lay nozzle down in gutter. Use a play-pipe holder or tie nozzle to any convenient post, in order to prevent pipe getting way from pipeman and doing damage.

For the larger engines, attach a line of hose on each side of the engine and connect into the Siamese of a deluge set.

With the smaller size engines, it is usually more convenient to use a single line from one side of the engine; when deluge sets are not available, single lines may be used on the larger engines. In the tables on pages 692 and 693, the length of hose and size of nozzle best adapted for testing engines of various sizes are given. In testing with the Siamesed lines, start the engines with both lines open and bring it up to speed; if the desired water pressure is not obtained, close the discharge gate on one line slowly until the gage indicates the proper pressure. Similarly, with a single line attached, the gate is closed slowly after engine has obtained its full speed until the desired pressure is obtained.

The supervisor can, from time to time, regulate this discharge gate to keep the desired water pressure, although if the crew operates the engine properly but little change will have to be made throughout the test. The engineer can be instructed to direct all his attention to operating his engine to full capacity, and the supervisor or testing engineer can regulate the water pressure, take the readings of the revolution counter, steam, water and suction gages, while his assistant takes readings of the nozzle pressure throughout the test.

When Siamesed lines are used, should the engine not be able to maintain the desired water pressure with one line shut off entirely, add another length of hose to each side, or use a nozzle ⅛-inch smaller. With single lines, when the engine cannot maintain the desired pressure without undue throttling of the discharge valve, use a smaller nozzle or add another length of hose. The nozzle readings should, if possible, be over 40 pounds, as below this point readings must be very nearly constant to give accurate results.

Should water pressure at the engine be too high with both lines wide open, use a larger nozzle or cut out a length of hose from each side.

Relief valves should be closed, sprinkler used only as needed, and feed pumps operated regularly. The capacity test should last at least 20 minutes from the time the engine reaches full speed. During this time the water pressure at the engine should be constant and such as to give a net water pressure over the suction pressure of 100 to 120 pounds. Unless the rubber tires cause undue vibration, a modern engine, if in good condition, can safely run for an indefinite period at 400 to 425 feet of piston travel per minute, that is, 300 to 320 revolutions for an 8-inch stroke.

It is usually better to hold about 10 pounds over the pressure actually required, when the water pressure fluctuates much, as most engineers read the top of swing of a gage needle, while the supervisor, of course, should read the middle of the vibration. Gages may be throttled to prevent excessive vibration, but should always show some vibration to get true readings. A better method of preventing excessive vibration of needle on gage is to attach a small air chamber to the connection near the gage; such an appliance is shown attached to gage used on Pitot tube. During the capacity test, the supervisor should read counter (exactly at minute) and steam, water and suction gages each minute in regular order, and note the handling and stoking, feed water, leaks, uneven steam pressure, blowing off, foaming of boiler, accidents, and the other little details which his experience teaches him to observe. Meanwhile the supervisor's assistant should read the nozzle pressure every ¼ minute. Special care should be taken in reading the nozzle pressure. The Pitot should be held in the middle of the stream, with the tip about one-half the diameter of the bore from the end of the nozzle. Gage should be horizontal or vertical, according to the position in which it was calibrated, and at the same level as the end of the nozzle. This is shown on Plate III.

HIGH PRESSURE TEST.—After a run of 20 minutes in which there were no serious interruptions to readings, and pressure was maintained at an average of at least 100 pounds net, stop stoking; shut down, close discharge gates, partly open churn valve and get steam down to between 70 and 80 pounds, drawing fire if necessary. Then start engine slowly, and gradually close churn valve tight. See that all other openings, feed pumps, sprinklers, relief cocks, etc., are shut. Let engine turn in this condition for one or

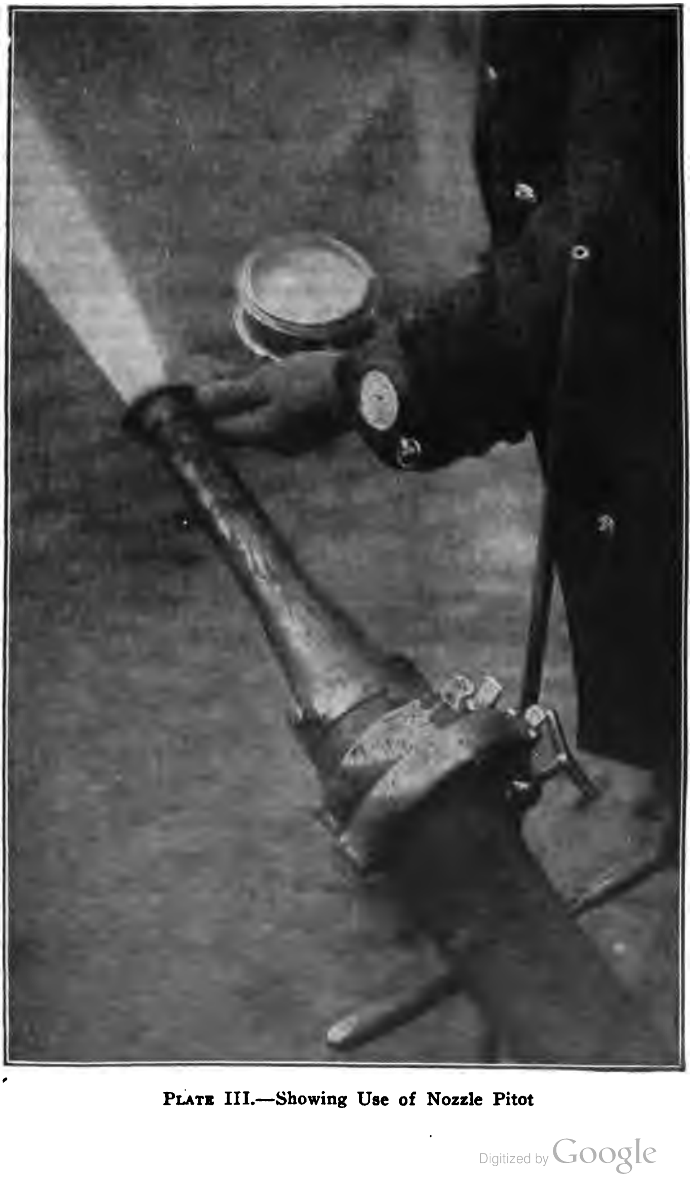


PLATE III.—Showing Use of Nozzle Pitot

two minutes; observe the number of revolutions, and the water, steam and suction (now static) pressures; note any uneven motion of engine, blowing through of steam or imperfect valve setting, leaks in steam or water ends, or fittings, etc. If pumps are in good condition and valves set correctly, speed should not be over one revolution in 10 seconds in any modern type engine. (This does not apply to a Silsby or a Button.) With 70 pounds steam and 50 pounds suction, water pressure will reach about 250 pounds; this is perfectly safe and not a severe test, as such pressures are frequently met in operation when long lines are used.

VALVE TESTS.—After taking the observations for the high pressure test, shut off throttle of engine and open cylinder drips. Note the drop in water pressure for say one-half minute. The manner in which this pressure holds up is an indication of the condition of the discharge valves. A drop of not over 15 pounds in one-half minute, provided there are no external leaks visible around the pump, indicates a fairly good condition of the valves.

SUCTION TEST.—If the engine has been tested at a hydrant, its ability to draft may be determined as follows, provided it is equipped with a compound suction gage or one of the suction caps is tapped to receive a compound gage: Disconnect engine from hydrant while there is still some steam pressure on boiler, put both suction caps on tight, open one of the discharge gates and then open throttle, allowing engine to run at a moderate speed, observe the reading of the compound gage while running, and also after shutting down. The drop of the vacuum after shutting down is an indication of the condition of the suction valves, provided all joints are good.

TO FIGURE DISPLACEMENT.—(Displacement is figured as indicated for sample test, pages 688 and 689.) In averaging the nozzle, steam, water and suction pressures, subtract ½ of first and last readings from sum of readings used (see page 689 and sample test sheet). Average the nozzle pressure during a period in which the engine ran steadily, water pressure was well maintained and the nozzle pressure varied the least. When possible, use a 20-minute period in figuring the displacement; if for any reason there is much variation in the nozzle pressure, say over 10 per cent during any one minute, select as long a period as possible, but at least 10 minutes, during which the pressure has been well maintained. Correct for gage error. Take out corresponding gallons from table, pages 700 and 701 interpolating for odd pressures or for odd-size nozzles.

Example: 1½" nozzle, 61 pounds nozzle pressure:
62 pounds nozzle pressure gives........................... 525 gallons
60 " " " " .... 517 gallons

or 2 pounds give a difference of........................... 8 gallons
and 1 pound gives ½ of this, or........................... 4 gallons
Therefore, 61 pounds nozzle pressure...................=517+4
=521 gallons

Example: 1 9/16" nozzle, 60 pounds nozzle pressure:
60 pounds through 1⅝" nozzle gives...................... 607 gallons
60 " " 1½" " " .... 517 gallons

or ⅛" difference in nozzle diameter gives.................. 90 gallons
and 1/16" " " " " " .... 45 gallons
Therefore, 1 9/16" nozzle at 60 pounds gives............... 517+45
=562 gallons

For odd-size nozzles, the discharge can be accurately obtained by using the formula on page 696.

Divide the average gallons discharged by the average revolutions per minute to obtain the actual net displacement of the pumps. The nominal displacement will be found from the table, page 690, allowing for the pump rods. The dimension of the pumps, such as stroke, diameter of pump barrel and pump rods, should be accurately measured, if in question. The difference between actual and nominal displacements is the slip, which should be from 3 to 5 per cent of the nominal displacement in a new engine (6 per cent in a rotary); of this, about ½ per cent is due to the feed water (1 per cent with a Button or Silsby engine). After engine has been in use a few months, slip will generally increase about 1 per cent; thereafter, if valves and packings are given proper attention, there should be only a slight increase. A slip of 10 per cent or over indicates broken or displaced valve springs, and more than this, a badly worn plunger or pump barrel, or possibly a leaky suction. In a rotary, the wear is principally in the pump cam slides, which will also stick at times, causing increased slip even if not worn.

TO FIGURE CAPACITY.—When the engine is run for 20 minutes at a uniform speed during the displacement test, the average discharge measured at the nozzle by the Pitot is the capacity of the engine. If only a 10-minute period of the run is used for figuring the displacement, the capacity of the engine is determined by multiplying the actual displacement (found in the displacement test) by the average revolutions per minute during a 20-minute period in which the engine worked at its full capacity. Steam, water and suction pressures during the capacity run should be averaged and corrected for gage error. In figuring percentage of capacity delivered, for a new fire engine, it is well to use contract figures for the rated capacity which the engine is guaranteed to deliver. A capacity due to a piston travel of 400 to 420 feet per minute (300 to 315 revolutions for 8-inch stroke) less a 3 per cent allowance for slip, is reasonable for a modern engine; older types vary considerably.

AUTOMOBILE AND MOTOR DRIVEN FIRE ENGINES

In so far as they apply, the same tests are desirable for automobile and motor driven pumping engines as for steam fire engines; the same methods for measuring the water discharged, calibrating (testing) water gauges, calculating the actual and nominal displacement and slip of the pumps, and averaging the net water pressure may be used. Valve and suction tests may be made in much the same manner as with steam fire engines, for piston or rotary displacement pumps; for centrifugal or rotary gear pumps, they will not apply.

Owing to the characteristics of the gasoline motor, certain modifications and additional tests are advisable. The capacity test should be run longer than is usually necessary with a steam engine. It is suggested that, for acceptance, engines of this type be required to deliver their full rated capacity at 120 pounds average net pressure for 2 hours, 50 per cent. of their rated capacity at 200 pounds average net pressure for ½ hour, and 33 per cent. of their rated capacity at 250 pounds average net pressure for ½ hour. Tests should preferably be made when drafting with about 10 feet of lift, especially if the engine may be required to draft water from a river, canal or cistern when in service. With a motor driven pump the high pressure test recommended on page 682 for steam engines becomes inadvisable. The ½-hour runs at high pressures serve to show the action of motor and pump under high pressures, and whether the gear ratios are properly arranged. The tables on pages 692 and 693 may be used to determine the length of hose and size of nozzles to be used with an engine of any given or guaranteed capacity. If two streams are preferred for the capacity test, the tables beginning on page 702 will be found convenient in laying out the length of hose and size of nozzles to be used. If the relief valve connection between discharge and suction side of pump is small or tortuous, it may be desirable to make an additional test with a 1⅛-inch shut-off nozzle on a line of about 300 feet in length, and with the engine pumping at 120 pounds pressure. The relief valve should be set to operate at about 10 pounds higher than the pressure to be carried, and when the nozzle is closed should permit the engine to run with an increase of not over 30 pounds pressure. The motor should start the pump readily with the hand relief valve open and the discharge gates closed.

For a two-hour run, nozzle and engine pressures may be recorded every 5 minutes, after the engine is brought up to speed, as with any reliable motor the speed and pressure will be nearly uniform. If it is inconvenient to attach a continuous reading counter to the pump, the speed may be taken for one minute, during each five-minute interval, using a speed counter. On some makes of pumps it is feasible to take the pump speed directly from the end of the pump shaft, by removing a foot board or bracket; on other makes, speed may be taken at the engine, on the end of a circulating pump shaft, timing shaft, or possibly on the fan drive-wheel shaft; if pump speed is obtained, the engine speed may be computed from the gear ratio. Notes should be made of any faults of construction, such as: Clutch slipping, absence of locks or stops for control levers, inadequate gasoline or lubricating oil supply, inaccessibility of parts, magneto and sparking circuit not waterproof, etc. The feed of lubricating oil is especially important in an automobile pump, where many parts are enclosed or not quickly accessible, and should be carefully looked into by the supervisor.

A. L. A. M. Formula for Horse-Power of Gasolene Motors.

$$\text{Horse-Power} = \frac{\text{Bore} \times \text{Bore} \times \text{No. of Cylinders}}{2.5}.$$

Example.—Six-cylinder motor, 4½-inch bore.

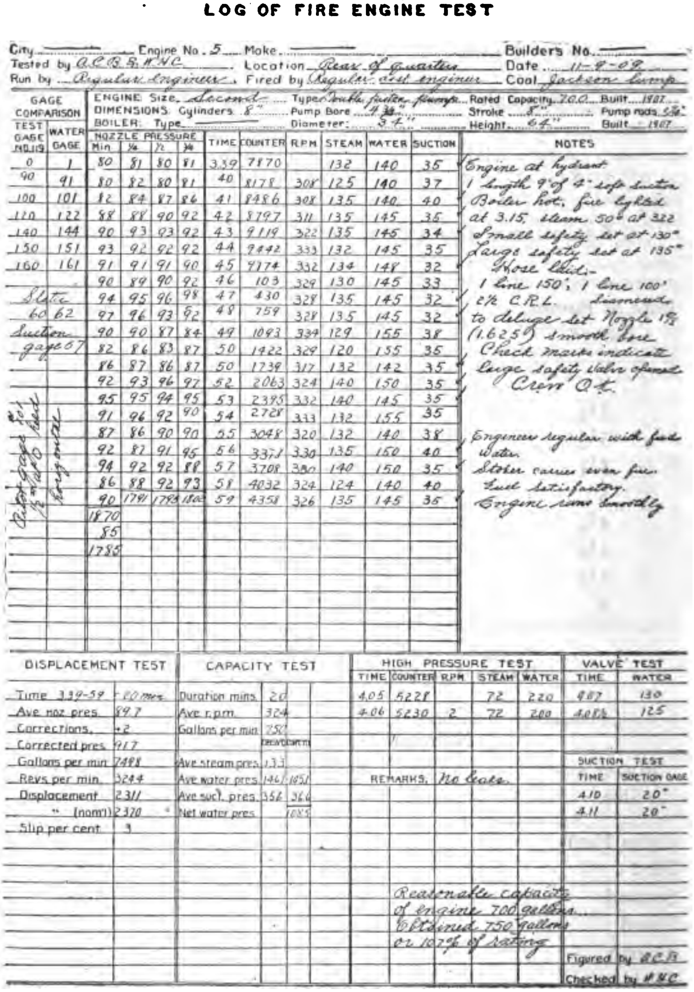
$$\text{H-P.} = \frac{4\tfrac{1}{2} \times 4\tfrac{1}{2} \times 6}{2.5} = 48.6.$$

Reasonable Capacities of Modern Fire Engines.

Bore of Pumps, Inches.	Stroke, Inches.	Capacity, Gallons per Minute.
6	9	1,100
5¾	8 or 9	1,000
5½	8	900
5¼	8 or 9	850
5	8	750
4¾	8	700
4½	7 or 8	600
4¼	7 or 8	550
4	7	500

Rated Capacity of Silsby Engines.

Maker's Size.	Nominal Displacement per Revolution, Gallons.	Rated Capacity, Gallons per Minute.
Extra First	1.261	1,000
First	1.141	900
Second	0.952	700
Third	0.804	600
Fourth	0.675	500
Fifth	0.513	400



LOG OF FIRE ENGINE TEST

City ——— Engine No. 5 Make ——— Builders No. ———
Tested by A.C.B. & H.N.C. Location Rear of quarters Date 11-9-09
Run by Regular engineer. Fired by Regular asst engineer Coal Jackson lump

ENGINE Size Second Type Double piston pump Rated Capacity 700 Built 1907
DIMENSIONS Cylinders 8" Pump Bore 4¾" Stroke 8" Pump rods 5⅜"
BOILER: Type ——— Diameter: 34" Height 64" Built 1907

GAGE COMPARISON TEST GAGE NO.119	WATER GAGE	NOZZLE PRESSURE Min	¼	½	¾	TIME	COUNTER	RPM	STEAM	WATER	SUCTION
0	1	80	81	80	81	3.39	7870		132	140	35
90	91	80	82	80	81	40	8178	308	125	140	37
100	101	82	84	87	86	41	8486	308	135	140	40
120	122	88	88	90	92	42	8797	311	135	145	35
140	144	90	93	93	92	43	9119	322	135	145	34
150	151	93	92	92	92	44	9442	333	132	145	35
160	161	91	91	91	90	45	9774	332	134	148	32
		90	89	90	92	46	103	329	130	145	33
Slate		94	95	96	98	47	430	328	135	145	32
60	62	97	96	93	92	48	759	328	135	145	32
Suction		90	90	87	84	49	1093	334	129	155	38
gage 67		82	86	83	87	50	1422	329	120	155	35
		86	87	86	87	50	1739	317	132	142	35
		92	93	96	97	52	2063	324	140	150	35
Pitot gage for 1⅝" head	Engineer	95	95	94	95	53	2395	332	140	145	35
		91	96	92	90	54	2728	333	132	155	35
		87	86	90	90	55	3048	320	132	140	38
		92	87	91	95	56	3371	330	135	150	40
		94	92	92	88	57	3708	380	140	150	35
		86	88	92	93	58	4032	324	124	140	40
		90	1791	1793	1800	59	4358	326	135	145	35
		1870									
		85									
		1785									

NOTES

Engine at hydrant
1 length 9' of 4" soft suction
Boiler hot, fire lighted
at 3.15, steam 50# at 3.22
Small safety set at 130#
Large safety set at 135#
Hose laid:-
1 line 150', 1 line 100'
2½ C.R.L. Siamesed
to deluge set Nozzle 1⅝
(1.625) smooth bore
Check marks indicate
large safety valve opened
Crew O.K.

Engineer regular with feed water.
Stoker carries even fire.
Fuel satisfactory.
Engine runs smoothly

DISPLACEMENT TEST	
Time 3.39-59	20 mins
Ave noz pres.	89.7
Corrections.	+2
Corrected pres.	91.7
Gallons per min	749.8
Revs per min.	324.4
Displacement	2.311
" (nom'l)	2.320
Slip per cent	.3

CAPACITY TEST		
Duration mins.	20	
Ave r.p.m.	324	
Gallons per min	750	
	DECIMAL	CORRECTED
Ave steam pres.	133	
Ave water pres.	146.1	185.1
Ave suct. pres.	35.6	36.6
Net water pres.		108.5

HIGH PRESSURE TEST				
TIME	COUNTER	RPM	STEAM	WATER
4.05	5228		72	220
4.06	5230	2	72	200

REMARKS. No leaks.

VALVE TEST	
TIME	WATER
4.07	130
4.08½	125

SUCTION TEST	
TIME	SUCTION GAGE
4.10	20"
4.11	20"

Reasonable capacity
of engine 700 gallons.
Obtained 750 gallons
or 107% of rating

Figured by A.C.B.
Checked by H.N.C.

CALCULATIONS FOR ENGINE TESTS.

(FOR TEST ON OPPOSITE PAGE.)

DISPLACEMENT TEST.

AVERAGE DISCHARGE.

To obtain Average Nozzle Pressure;
Sum Column "Min."………. 1,870
Subtract ½ sum of first and last figures……………… 85

1,785
Sum Column "¼"………… 1,791
" " "½"………… 1,795
" " "¾"………… 1,802

Divide by 80…………) 7,173

Average Nozzle Reading.. 89.7
Correction from Gage Test Sheet…………………… + 2.0

Average Nozzle Pressure. 91.7

From Discharge Tables for 1⅝" Nozzle:
92 lbs. gives………… 751 gallons.
90 " " ………… 743 "

2 " " ………… 8 "
1.7 lbs. gives……… 6.8 "
Then 91.7 lbs. = 749.8 gallons.

AVERAGE R. P. M.

Counter at 3.59…………… 4,858
" " 3.89…………… 7,870

Divide by 20…………) 6,488

Average R. P. M. = 324.4

ACTUAL DISPLACEMENT.

$$\frac{\text{Average Discharge}}{\text{Average R. P. M.}} = \frac{749.8}{324.4} = 2.311$$

NOMINAL DISPLACEMENT.

From Engine Displacement Table:
4¾" Bore, 8" Stroke……… 2.455
1¼" Pump Rod…………… .085

Nominal Displacement = 2.370

SLIP, IN PER CENT.

$$\frac{\text{Nom. Displacem't} - \text{Act. Displacem't}}{\text{Nominal Displacement}}$$

$$\frac{2.370 - 2.311}{2.370} = 3\%.$$

CAPACITY TEST.

AVERAGE R. P. M.

Same as for Displacement Test in this case.

GALLONS PER MINUTE.

Same as for Displacement Test in this case.

AVERAGES OF PRESSURES.

Steam:
Sum of Column…………… 2,787
½ of first and last figures….. 133

Divide by 20…………) 2,654

Average Steam Reading.. 132.7

Water:
Sum of Column………… 3,065
½ of first and last figures… 142.5

Divided by 20………) 2,922.5

Average Reading……. 146.1
Correction from Test of Gage and Test Sheet, for Gage No. 119…………… − 1.0

Average Water Pressure 145.1

Suction:
Sum of Column…………… 746
½ of first and last figures….. 35

Divide by 20…………) 711

Average Reading……… 35.6
Correction from Test of Gage + 1.0

Average Suction Pressure 36.6

Net Pressure:
Average water pressure…. 145.1
Average suction pressure.. 36.6

Average net pressure.. 108.5

PERCENTAGE OF CAPACITY OBTAINED.

Reasonable capacity of Pumps based on 400 Ft. Piston Travel per Min. = 700 gals.
Obtained at Test……… 750 gals.
or 107% of Rating.

ENGINE DISPLACEMENT TABLE.

DOUBLE PUMPS.

PLUNGER DISPLACEMENT. GALLONS PER REVOLUTION.

Bore of Pump Inches.	Stroke in Inches. 7	8	9
3 1/2	1.166	1.333	1.500
3 5/8	1.251	1.430	1.609
3 3/4	1.339	1.530	1.721
3 7/8	1.430	1.634	1.838
4	1.523	1.740	1.958
4 1/8	1.620	1.851	2.082
4 1/4	1.719	1.965	2.211
4 3/8	1.822	2.083	2.343
4 1/2	1.928	2.203	2.478
4 5/8	2.036	2.327	2.618
4 3/4	2.148	2.455	2.762
4 7/8	2.263	2.586	2.909
5	2.380	2.720	3.060
5 1/8	2.500	2.858	3.215
5 1/4	2.624	2.999	3.374
5 3/8	2.750	3.143	3.536
5 1/2	2.880	3.291	3.702
5 5/8	3.012	3.442	3.872
5 3/4	3.147	3.597	4.047
5 7/8	3.286	3.755	4.225
6	3.427	3.917	4.407

PUMP ROD CORRECTION. GALLONS PER REVOLUTION.

Diameter of Pump Rods.	Stroke in Inches. 7	8	9
1 "	0.047	0.054	0.061
1 1/16	0.053	0.061	0.069
1 1/8	0.060	0.069	0.078
1 3/16	0.067	0.077	0.087
1 1/4	0.074	0.085	0.096
1 5/16	0.081	0.093	0.105
1 3/8	0.089	0.102	0.115
1 7/16	0.098	0.112	0.126
1 1/2	0.107	0.122	0.138
1 9/16	0.116	0.133	0.150
1 5/8	0.126	0.143	0.162
1 11/16	0.136	0.155	0.174
1 3/4	0.146	0.167	0.188

Subtract pump rod correction from plunger displacement to obtain correct displacement of engine.

For single-pump engines, use one-half of result obtained.

For single-acting pumps, do not subtract pump rod correction.

Example: Engine with 5¼-inch pump, 9-inch stroke and 1½-inch pump rod.

From Table above:

Displacement of Plunger = 3.374 gallons.
Correction for Rod = 0.138 gallons.

Nominal Displacement = 3.236 gallons

Below is given a table for use when engines are worked at draft, either in actual service or in testing. A study of it will show that where a high lift is necessary, small suctions will restrict the capacity of an engine; the table indicates clearly what sizes are necessary under different conditions. The figures are based on the ability of the pumps to maintain a vacuum of 23 inches.

TABLE SHOWING MAXIMUM LIFT, IN FEET, WHEN DRAFTING VARIOUS QUANTITIES OF WATER WITH A FIRE ENGINE IN GOOD CONDITION.

Quantity of Water, Gallons per Minute.	MAXIMUM LIFT IN FEET, ENGINE DRAFTING.					
	3" Suction.	3½" Suction.	4" Suction.	4½" Suction.	5" Suction.	
300	16	20	22½	24	24½	3 lengths of suction.
400	8½	17	20	22½	24	
500		12½	18½	20½	23	
600		7	15	19½	21	
700		4½	11	17	19½	
800			6½	14½	19	2 lengths of suction.
900			6	11½	17	
1,000				8	14½	
1,100				7½	12	
1,200				4	9½	
1,300					6½	
1,300	1 length of suction.				9½	

TABLE OF HOSE AND NOZZLES FOR TESTING ENGINES, USING SIAMESED LINES.

NOTE.—Connect Lines to a Deluge Set Provided with a Short Lead of 3½- or 4-Inch Hose. Use Only Smooth-Bore Nozzle and of the Diameter Given. By Regulating One of the Discharge Gates, Pressure can be Kept Nearly Constant and from Three-quarters to Full Capacity Obtained.

Size.	Bore of Pump.	Reasonable Capacity, Gallons per Minute.*	NUMBER AND LENGTH OF LINES AND SIZE OF NOZZLE NEEDED TO DELIVER THE REASONABLE CAPACITY AT THE DESIRED PRESSURE AT THE ENGINE.			
			100 Pounds.	120 Pounds.	140 Pounds.	160 Pounds.
Double Extra First	6"	1,100	2–50' lines of 3" or 3–50' lines of 2½" 2" Nozzle	2–100' lines of 3" or 3–100' lines of 2½" 2" Nozzle	2–150' lines of 3" or 3–150' lines of 2½" 2" Nozzle	2–200' lines of 3" or 3–200' lines of 2½" 2" Nozzle
Extra First	5¾"	1,000	2–50' lines of 2½" 2" Nozzle	1–100' line of 2½" and 1–50' line of 2½" 2" Nozzle	2–100' lines of 3" 2" Nozzle	2–150' lines of 2½" 2" Nozzle
First	5½"	900	2–50' lines of 2½" 1⅞" or 2" Nozzle	1–100' line of 2½" and 1–50' line of 2½" 1⅞" Nozzle	2–100' lines of 2½" 1⅞" Nozzle	2–150' lines of 2½" 1⅞" Nozzle
Second	5"	750	2–50' lines of 2½" 1¾" Nozzle	2–100' lines of 2½" 1¾" Nozzle	2–150' lines of 2½" 1¾" Nozzle	2–250' lines of 2½" 1¾" Nozzle
	4¾"	700	2–50' lines of 2½" 1⅝" Nozzle	2–100' lines of 2½" 1⅝" Nozzle	2–150' lines of 2½" 1⅝" Nozzle	2–250' lines of 2½" 1⅝" Nozzle
Third	4½" or 4¼"	600 or 550	1–100' line of 2½" and 1–150' line of 2½" 1⅝" Nozzle	1–100' line of 2½" and 1–150' line of 2½" 1½" Nozzle	1–100' line of 2½" and 1–200' line of 2½" 1½" Nozzle	2–250' lines of 2½" 1½" Nozzle
Fourth	4"	500	2–100' lines of 2½" 1⅜" Nozzle	2–200' lines of 2½" 1⅜" Nozzle	2–300' lines of 2½" 1⅜" Nozzle	1–100' line of 2½" 1⅜" Nozzle ‡
Fifth	3⅝"	400	2–100' lines of 2½" 1¼" Nozzle	1–100' line of 2½" 1¼" Nozzle ‡	1–150' line of 2½" 1¼" Nozzle ‡	1–200' line of 2½" 1¼" Nozzle ‡

* Based on about 400' piston travel per minute. ‡ Single lines; deluge set omitted.

NOTE.—If hose has not smoothest lining, shorter lines or a larger nozzle may be required; if hose is slightly larger than given on page 20, it may be necessary to use longer lines or a smaller nozzle.

TABLE OF NOZZLES FOR TESTING ENGINES, USING SINGLE 50-FOOT LINES OF HOSE.

NOTE.—Connect Line to Nozzle; Bring Engine to Speed and Regulate Discharge Gate; if Desired Pressure Cannot be Obtained, Use Nozzle ⅛" Smaller or Add Another Length of Hose.

Size.	Bore of Pump.	Reasonable Capacity, Gallons per Minute.*	SIZE OF NOZZLE NEEDED TO DELIVER THE REASONABLE CAPACITY AT THE DESIRED PRESSURE AT THE ENGINE.			
			100 Pounds.	120 Pounds.	140 Pounds.	160 Pounds.
				Single 50-foot Line of 3" hose		
First	5½"	900	2¼"	2¼" or 2"	2"	1⅞" or 1¾"
				Single 50-foot Line of 2½" hose		
Second	5" 4¾"	750 700	2" 1⅞"	1⅞" 1¾"	1⅞" 1¾"	1⅝" 1⅝"
Third	4½" 4¼"	600 550	1¾" or 1⅝" 1⅝"	1⅝" or 1½" 1½"	1½" 1⅜"	1⅜" 1⅜"
Fourth	4"	500	1½"	1⅜"	1⅜"	1¼"
Fifth	3⅝"	400	1¼"	1¼"	1⅛"	1⅛"

* Based on about 400' piston travel per minute.

FIRE STREAM TABLES

These tables are arranged to show the pressures required at the hydrant or fire engine, while stream is flowing, to maintain nozzle pressures given in the first columns, through various lengths of 2½-, 3- and 3½-inch rubber lined hose in single lines and two lines of 2½-inch hose siamesed.

Nozzle pressures of 40 to 60 pounds from 1⅛- and 1¼-inch nozzles will give streams which may be classed as good and which can be handled without special appliances; for deluge sets, turret pipes, etc., with 1½-inch and larger nozzles, 60 to 90 pounds nozzle pressure is desirable for effective fire fighting; the height, area and general character of the building are factors in determining at what pressure a stream may be considered good, as well as in determining whether a nozzle is of sufficient size to furnish an effective stream, nothing less than 1⅛-inch being considered as effective for outside work, except for fires in small buildings. In this connection it should be noted that a 1- or 1⅛-inch ring tip delivers a stream about ⅛ inch smaller than the diameter of the tip.

The pressure at the hydrant or fire engine is that indicated by a gage attached to the hydrant or fire engine while the stream is flowing. The pressure at the nozzle is that indicated by a Pitot gage held in the stream.

The hydrant (or engine) pressures are obtained by adding to the nozzle pressure the friction loss in the hose, and also the small additional loss in the hydrant outlet or engine discharge.

Friction losses in hose are based on tests of best quality rubber-lined fire hose and are for 100-foot lengths measured without pressure applied. Diameters of hose, as measured under 75 pounds pressure, assumed as the average working condition, were as follows: For nominal 2½-inch, 2.575 or about 2 9/16 inches; for nominal 3-inch, 3.125 or 3⅛ inches; for nominal 3½-inch, 3.685 or about 3 11/16 inches.

The smoothness of the lining has a very considerable effect on the friction loss, some samples tested showing losses 50 per cent in excess of those given. A slight variation in diameter also produces a marked difference in friction loss; in the case of 2½-inch hose, a variation of 1/16 inch in diameter will result in 10 per cent difference in loss. If properly beveled 2½-inch couplings are used on 3-inch hose, the loss of pressure due to them will be less than 5 per cent of that gained by the use of the larger hose. For instance, for a flow of 300 gallons per minute, the loss in 2½-inch hose will be about 21 pounds, in 3-inch hose with 3-inch couplings about 8 pounds, and in 3-inch with 2½-inch couplings about 8½ pounds.

For siamesed lines, an allowance was made for the loss in the siamese connection and for 20 feet of 3½-inch lead hose.

The pressures given are for the nozzle at the same elevation as the hydrant or engine discharge outlet. Add or subtract 1 pound to the pressure given for each 2 1/3 feet difference in elevation. The arrangement of the table allows a comparison to be readily made of the results obtainable with 3-inch hose and siamesed lines against single lines of 2½-inch hose.

An approximate formula for the friction loss in 2½-inch hose is as follows: Pressure loss in each hundred feet, in pounds $= 2Q^2 + Q$, where Q is the quantity in gallons divided by 100.

The approximate figure for the friction loss in other sizes for the same quantity flowing can be obtained by dividing the friction loss in 2½-inch hose by the following factors, shown in bold face type:

SINGLE LINES

2¾"	3"	3½"	4"	4½"	5"
1.66	2.6	5.8	11.0	19.5	32.0

SIAMESED LINES OF EQUAL LENGTH

2-2½"	3-3½"	2-3"	3-3"	1-3" 1-2½"
3.6	7.75	9.35	20.4	6.1

4-2½"	6-2½"	4-3"	2-2½" 1-3"	2-3" 1-2½"
12.4	27.0	32.0	11.5	15.0

RATING OF GASOLINE MOTORS

$$\frac{(\text{Bore})^2 \times \text{Number of Cylinders}}{2\frac{1}{2}} = \text{H. P.}$$

Bore, Inches	Horse Power		
	2 Cyl.	4 Cyl.	6 Cyl.
3	7.2	14.4	21.6
3¼	8.4	16.9	25.3
3½	9.8	19.6	29.4
3¾	11.2	22.5	33.7
4	12.8	25.6	38.4
4¼	14.5	29.9	43.4
4½	16.2	32.4	48.6
4¾	18.1	36.1	34.2
5	20.0	40.0	60.0
5¼	22.1	44.1	66.2
5½	24.2	48.4	72.6
5¾	26.5	52.9	79.4
6	28.8	57.6	85.4
6¼	31.2	62.5	93.7
6½	33.8	67.6	101.4
6¾	36.4	72.9	109.3
7	39.2	78.4	117.6
7¼	42.1	84.1	126.2
7½	45.0	90.0	135.0
7¾	48.1	96.1	144.2
8	51.2	102.4	153.6

TABLE OF NOZZLE FACTORS

For use in obtaining discharge from smooth nozzle larger than those given in tables on pages 704 and 705, when nozzle pressure is obtained with a Pitot gage.

The discharge in gallons per minute is equal to the square root of the pressure multiplied by the factor.

Diameter of the nozzle in inches.	FACTORS.	
	For Fresh Water.	For Salt (sea) Water.
2	118.96	117.45
2¼	150.56	148.64
2½	185.88	183.50
2¾	224.91	222.05
3	267.66	264.25
3¼	314.13	310.13
3½	364.32	359.68
3¾	418.23	412.90
4	475.85	469.79
4¼	537.19	530.35
4½	602.25	594.58
4¾	671.02	662.48
5	743.51	734.03
6	1,070.64	1,057.00

For any size nozzles, the discharge, for fresh water, can be determined by the following formula:

Gallons per minute $= 29.83\ c\ d^2 \sqrt{p}$.

Where $d =$ diameter of nozzle in inches, measured to 1/1000 of an inch.

$p =$ pressure recorded on Pitot gage in pounds.

$c =$ a constant, varying from 0.990 for 1-inch nozzle to 0.997 for 6-inch nozzle.

For ordinary use, the formula can be reduced to:

Gallons per minute $= 29.7\ d^2 \sqrt{p}$.

FORMULA FOR OBTAINING APPROXIMATE NOZZLE OR ENGINE PRESSURES, LENGTH OF LINE AND SIZE OF NOZZLE BEING GIVEN.

$$\text{Nozzle Pressure in pounds} = \frac{\text{Engine Pressure}}{1.1 + K\,L}$$

Engine Pressure in pounds = Nozzle Pressure $(1.1 + K\,L)$.

L = Number of 50-foot lengths of hose.

K = Constant, varying with size of nozzle and hose. See Table following.

Size Nozzle, Inches.	K FOR					
	Single Line 2½" Hose.	Single Line 3" Hose.	Single Line 3½" Hose.	Two 2½" Lines Siamesed. *	Two 3" Lines Siamesed. *	3 Lines 2½" Hose. *
1	.105	.038	....	025	....	....
1⅛	.167	.062	....	.043	....	....
1¼	.248	.092	.039	.066	.023	.028
1⅜	.341	.137	.059	.096	.034	.043
1½	.505	.192	.084	.135	.051	.061
1⅝	.680	.266	.113	.184	.068	.084
1¾	.907	.351	.152	.242	.093	.115
2	1.550	.605	.250	.418	.157	.190

* Allowance is made for loss in deluge set; these values will also give approximately correct figures for turret nozzles and water tower, except that in the latter, pressure equal to 0.434 times the height of tower must be subtracted from the engine pressure, before solving for nozzle pressure.

[EDITOR'S NOTE.—The value of K for 2½-inch hose and any size nozzle can be found by squaring the diameter of the nozzle, squaring the answer and dividing by 10. For any other size of hose or any siamesed lines, K can be found by dividing the K for 2½-inch hose by the Factor for the other hose given on page 696.]

EFFECTIVE REACH OF FIRE STREAMS.

SHOWING THE DISTANCE IN FEET FROM THE NOZZLE AT WHICH STREAMS WILL DO EFFECTIVE WORK WITH A MODERATE WIND BLOWING. WITH A STRONG WIND THE REACH IS GREATLY REDUCED..

Pressure at Nozzle.	Size of Nozzle.									
	1-Inch.		1⅛-Inch		1¼-Inch.		1⅜-Inch.		1½-Inch.	
	Vertical Distance, Feet.	Horizontal Distance, Feet.	Vertical Distance, Feet.	Horizontal Distance, Feet.	Vertical Distance, Feet.	Horizontal Distance, Feet.	Vertical Distance, Feet.	Horizontal Distance, Feet.	Vertical Distance, Feet.	Horizontal Distance, Feet.
20	35	37	36	38	36	39	36	40	37	42
25	43	42	44	44	45	46	45	47	46	49
30	51	47	52	50	52	52	53	54	54	56
35	58	51	59	54	59	58	60	59	62	62
40	64	55	65	59	65	62	66	64	69	66
45	69	58	70	63	70	66	72	68	74	71
50	73	61	75	66	75	69	77	72	79	75
55	76	64	79	69	80	72	81	75	83	78
60	79	67	83	72	84	75	85	77	87	80
65	82	70	86	75	87	78	88	79	90	82
70	85	72	88	77	90	80	91	82	92	84
75	87	74	90	79	92	82	93	84	94	86
80	89	76	92	81	94	84	95	86	96	88
85	91	78	94	83	96	87	97	88	98	90
90	92	80	96	85	98	89	99	90	100	91

NOTE.—Nozzle pressures are as indicated by Pitot tube. The horizontal and vertical distances are based on experiments by Mr. John R. Freeman, *Transactions*, Am. Soc. C. E., Vol. XXI.

FRICTION LOSS IN FIRE HOSE.

BASED ON TESTS OF BEST QUALITY RUBBER LINED FIRE HOSE.*

Flow, Gallons per Minute.	PRESSURE LOSS IN EACH 100 FEET OF HOSE, POUNDS PER SQ. INCH.				Flow, Gallons per Minute.	PRESSURE LOSS IN EACH 100 FEET OF HOSE, POUNDS PER SQ. INCH.		
	2½" Hose.	3" Hose.	3½" Hose.	2 Lines of 2½" Siamesed.		3" Hose.	3½" Hose.	2 Lines of 2½" Siamesed.
140	5.2	2.0	0.9	1.4	525	23.2	10.5	16.6
160	6.6	2.6	1.2	1.9	550	25.2	11.4	18.1
180	8.3	3.2	1.5	2.3	575	27.5	12.4	19.0
200	10.1	3.9	1.8	2.8	600	29.9	13.4	21.2
220	12.0	4.2	2.1	3.3	625	32.0	14.4	23.0
240	14.1	5.4	2.5	3.9	650	34.5	15.5	24.8
260	16.4	6.3	2.9	4.5	675	37.0	16.6	26.5
280	18.7	7.2	3.3	5.2	700	39.5	17.7	28.3
300	21.2	8.2	3.7	5.9	725	42.3	18.9	30.2
320	23.8	9.3	4.2	6.6	750	45.0	20.1	32.2
340	26.9	10.5	4.7	7.4	775	47.8	21.4	34.2
360	30.0	11.5	5.2	8.3	800	50.5	22.7	36.2
380	33.0	12.8	5.8	9.2	825	53.5	24.0	38.4
400	36.2	14.1	6.3	10.1	850	56.5	25.4	40.7
425	40.8	15.7	7.0	11.3	875	59.7	26.8	43.1
450	45.2	17.5	7.9	12.5	900	63.0	28.2	45.2
475	50.0	19.3	8.7	13.8	1,000	76.5	34.3	55.0
500	55.0	21.2	9.5	15.2	1,100	91.5	41.0	65.5

*Rough rubber lining is liable to increase the losses given in the table as much as 50 per cent.

DISCHARGE TABLE FOR SMOOTH NOZZLES.

NOZZLE PRESSURE MEASURED BY PITOT GAGE.

Nozzle Pressure in lbs. per sq. inch.	Nozzle Diam. in Inches. 1	1⅛	1¼	1⅜	1½	Nozzle Pressure in lbs. per sq. inch.	Nozzle Diam. in Inches. 1	1⅛	1¼	1⅜	1½
	Gallons per minute.						Gallons per Minute:				
5	66	84	108	125	149	60	229	290	357	434	517
6	72	92	113	137	163	62	233	295	363	441	525
7	78	99	122	148	176	64	237	299	369	448	533
8	84	106	131	158	188	66	240	304	375	455	542
9	89	112	139	168	200	68	244	308	381	462	550
10	93	118	146	177	211	70	247	313	386	469	558
12	102	130	160	194	231	72	251	318	391	475	566
14	110	140	173	210	249	74	254	322	397	482	574
16	118	150	185	224	267	76	258	326	402	488	582
18	125	159	196	237	283	78	261	330	407	494	589
20	132	167	206	250	298	80	264	335	413	500	596
22	139	175	216	263	313	82	268	339	418	507	604
24	145	183	226	275	327	84	271	343	423	513	611
26	151	191	235	286	340	86	274	347	428	519	618
28	157	198	244	297	353	88	277	351	433	525	626
30	162	205	253	307	365	90	280	355	438	531	633
32	167	212	261	317	377	92	283	359	443	537	640
34	172	218	269	327	389	94	286	363	447	543	647
36	177	224	277	336	400	96	289	367	452	549	654
38	182	231	285	345	411	98	292	370	456	554	660
40	187	237	292	354	422	100	295	374	461	560	667
42	192	243	299	363	432	105	303	383	473	574	683
44	196	248	306	372	442	110	310	392	484	588	699
46	200	254	313	380	452	115	317	401	495	600	715
48	205	259	320	388	462	120	324	410	505	613	730
50	209	265	326	396	472	125	331	418	516	626	745
52	213	270	333	404	481	130	337	427	526	638	760
54	217	275	339	412	490	135	343	435	536	650	775
56	221	280	345	419	499	140	350	443	546	662	789
58	225	285	351	426	508	145	356	450	556	674	803
60	229	290	357	434	517	150	362	458	565	686	817

Assumed coefficient of discharge = .99 .99 .99 .99¼ .99½

Note.—Coefficients of discharge are based on experiments by Mr. John R. Freeman, *Transactions* Am. Soc. C. E., Vols. XXI and XXIV.

DISCHARGE TABLE FOR SMOOTH NOZZLES.

NOZZLE PRESSURE MEASURED BY PITOT GAGE.

Nozzle Pressure in lbs. per sq. inch.	Nozzle Diam. in Inches.					Nozzle Pressure in lbs. per sq. inch.	Nozzle Diam. in Inches.				
	1⅝	1¾	1⅞	2	2¼		1⅝	1¾	1⅞	2	2¼
	Gallons per Minute.						Gallons per Minute.				
5	175	203	234	263	337	60	607	704	810	920	1167
6	192	223	256	292	369	62	617	716	823	936	1187
7	207	241	277	315	399	64	627	727	836	951	1206
8	222	257	296	336	427	66	636	738	850	965	1224
9	235	273	314	357	452	68	646	750	862	980	1242
10	248	288	330	376	477	70	655	761	875	994	1260
12	271	315	362	412	522	72	665	771	887	1008	1276
14	293	340	391	445	564	74	674	782	900	1023	1296
16	313	364	418	475	603	76	683	792	911	1036	1313
18	332	386	444	504	640	78	692	803	924	1050	1330
20	350	407	468	532	674	80	700	813	935	1063	1347
22	367	427	490	557	707	82	709	823	946	1076	1364
24	384	446	512	582	739	84	718	833	959	1089	1380
26	400	464	533	606	769	86	726	843	970	1102	1396
28	415	481	554	629	799	88	735	853	981	1115	1412
30	429	498	572	651	826	90	743	862	992	1128	1429
32	443	514	591	673	854	92	751	872	1002	1140	1445
34	457	530	610	693	880	94	759	881	1012	1152	1460
36	470	546	627	713	905	96	767	890	1022	1164	1476
38	483	561	645	733	930	98	775	900	1032	1176	1491
40	496	575	661	752	954	100	783	909	1043	1189	1506
42	508	589	678	770	978	105	803	932	1070	1218	1542
44	520	603	694	788	1000	110	822	954	1095	1247	1579
46	531	617	710	806	1021	115	840	975	1120	1275	1615
48	543	630	725	824	1043	120	858	996	1144	1303	1649
50	554	643	740	841	1065	125	876	1016	1168	1329	1683
52	565	656	754	857	1087	130	893	1036	1191	1356	1717
54	576	668	769	873	1108	135	910	1056	1213	1382	1750
56	586	680	782	889	1129	140	927	1076	1235	1407	1780
58	596	692	796	905	1149	145	944	1005	1257	1432	1812
60	607	704	810	920	1168	150	960	1114	1279	1456	1843

Assumed coefficient of discharge = .995 .995 .996 .997 .997

1-INCH SMOOTH NOZZLE.—

Nozzle Pressure Indicated by Pitot Gage.	Discharge, Gallons per Minute.	PRESSURES REQUIRED AT HYDRANT OR MAINTAIN NOZZLE PRESSURES GIVEN LENGTHS OF BEST QUALITY							
		Single 2½-inch Lines.							
		100 Feet.	200 Feet.	300 Feet.	400 Feet.	500 Feet.	600 Feet.	700 Feet	800 Feet.
20	132	25	30	35	39	44	49	53	58
25	148	31	37	43	49	55	60	66	72
30	162	38	44	51	58	65	72	78	85
35	175	44	52	59	67	75	83	91	98
40	187	50	59	68	77	86	94	103	112
45	198	56	66	76	86	96	106	115	125
50	209	62	73	84	95	106	117	128	139
55	219	68	80	92	104	116	128	140	152
60	229	75	88	101	114	127	140	153	166
65	238	81	95	109	123	137	151	165	179
70	247	87	102	117	132	147	162	177	192
75	256	93	109	125	141	157	173	189	205
80	264	99	116	133	150	167	183	200	217
85	272	105	123	141	159	177	195	212	230
90	280	111	130	149	167	186	205	224	243
95	287	117	137	157	177	196	216	236	256
100	295	123	144	165	185	206	227	247	268

2½- AND 3-INCH HOSE.

FIRE ENGINE, WHILE STREAM IS FLOWING, TO IN FIRST COLUMN, THROUGH VARIOUS 2½- AND 3-INCH RUBBER LINED HOSE.

		Single 3-inch Lines.				Two 2½-inch Lines Siamesed.			Nozzle Pressure Indicated by Pitot Gage.
1,000 Feet.	1,200 Feet.	800 Feet.	1,000 Feet.	1,200 Feet.	1,500 Feet.	1,000 Feet.	1,500 Feet.	2,000 Feet.	
68	77	35	39	42	48	33	40	46	**20**
84	95	43	48	52	59	41	49	57	**25**
99	112	52	57	62	70	49	59	68	**30**
114	130	60	66	72	81	57	68	79	**35**
130	148	68	75	82	92	65	78	90	**40**
145	165	77	84	92	103	72	86	99	**45**
160	182	85	93	102	114	80	95	110	**50**
175	199	93	102	112	125	88	105	121	**55**
192	218	102	112	122	137	96	114	132	**60**
207	235	110	121	131	148	103	122	141	**65**
222	252	118	130	141	159	111	132	152	**70**
237	269	127	139	151	170	120	142	164	**75**
251	285	135	148	161	181	128	151	175	**80**
266	302	143	156	170	191	135	159	184	**85**
280	...	151	165	180	202	143	169	195	**90**
295	...	158	173	189	211	150	177	204	**95**
310	...	167	183	199	223	157	186	215	**100**

1 1/8-INCH SMOOTH NOZZLE.—

Nozzle Pressure Indicated by Pitot Gage.	Discharge, Gallons per Minute.	PRESSURES REQUIRED AT HYDRANT OR FIRE NOZZLE PRESSURES GIVEN IN FIRST QUALITY 2½- AND									
		Single 2½-inch Lines.									
		100 Feet.	200 Feet.	300 Feet.	400 Feet.	500 Feet.	600 Feet.	700 Feet.	800 Feet.	1,000 Feet.	1,200 Feet.
20	167	28	35	42	49	56	64	71	78	92	107
25	187	35	44	53	62	71	79	88	97	115	133
30	205	42	52	63	73	84	95	105	116	137	158
35	221	49	61	73	85	97	110	122	134	158	183
40	237	55	69	83	96	110	124	138	151	179	206
45	251	62	77	93	108	123	139	154	169	200	230
50	265	69	86	103	120	137	154	171	188	222	256
55	277	76	94	112	131	149	168	186	204	241	278
60	290	83	103	123	143	163	183	203	223	263	304
65	301	89	111	132	154	175	197	218	240	283	326
70	313	96	119	142	165	188	211	234	257	303	....
75	324	103	128	152	177	202	227	252	276	325	....
80	335	110	136	162	188	215	241	267	294	....	....
85	345	116	144	171	199	226	254	282	309	....	....
90	355	123	152	181	210	240	269	298	327	....	....
95	365	130	160	191	222	252	283	314	....	....	....
100	374	136	168	201	233	265	297	329	..	....	...

2 1/2- AND 3-INCH HOSE.

ENGINE, WHILE STREAM IS FLOWING, TO MAINTAIN COLUMN, THROUGH VARIOUS LENGTHS OF BEST 3-INCH RUBBER LINED HOSE.

Single 3-inch Lines.							Two 2½-inch Lines Siamesed.					Nozzle Pressure Indicated by Pitot Gage.
400 Feet.	600 Feet.	800 Feet.	1,000 Feet.	1,200 Feet.	1,500 Feet.	1,800 Feet.	800 Feet.	1,000 Feet.	1,200 Feet.	1,500 Feet.	1,800 Feet.	
32	37	43	48	54	62	71	38	42	46	53	60	20
40	46	53	60	67	77	87	45	50	55	63	70	25
47	55	63	71	79	91	103	53	59	65	74	82	30
55	65	74	83	93	107	121	62	69	76	86	96	35
63	73	84	95	105	121	137	70	78	86	97	108	40
70	82	94	106	118	135	153	79	87	95	108	121	45
78	91	104	117	130	150	169	88	98	107	121	135	50
86	100	114	128	142	164	185	96	107	117	132	147	55
93	109	124	139	155	178	201	105	116	127	143	160	60
101	117	134	151	167	192	217	114	126	138	156	174	65
108	126	144	162	180	206	233	122	135	148	167	186	70
116	135	154	173	192	221	249	130	144	157	178	198	75
124	144	165	185	206	236	267	138	153	167	189	210	80
131	153	174	195	217	249	281	147	163	178	201	224	85
139	161	184	207	229	263	297	156	172	188	212	237	90
146	170	194	218	242	277	313	164	181	198	224	249	95
154	178	203	228	253	290	....	172	190	208	235	261	100

1 1/4-INCH SMOOTH NOZZLE.—

Nozzle Pressure Indicated by Pitot Gage.	Discharge, Gallons per Minute.	PRESSURES REQUIRED AT HYDRANT OR FIRE PRESSURES GIVEN IN FIRST COLUMN, 2½- AND 3-INCH									
		Single 2½-inch Lines.									
		100 Feet.	200 Feet.	300 Feet.	400 Feet.	500 Feet.	600 Feet.	700 Feet.	800 Feet.	1,000 Feet.	1,200 Feet.
20	206	32	42	53	64	75	85	96	107	128	149
25	230	40	53	66	79	92	105	118	131	158	184
30	253	48	63	79	95	110	126	142	157	189	220
35	273	55	73	91	109	127	145	163	181	217	253
40	292	63	83	104	124	144	165	185	206	246	287
45	309	70	93	116	138	161	183	206	229	274	319
50	326	78	103	128	153	178	203	228	253	303	....
55	342	86	113	140	167	194	222	249	276	330	....
60	357	93	123	152	182	211	241	270	300	....	....
65	372	101	133	164	196	228	260	292	323	....	....
70	386	108	142	176	210	244	278	312	....	....	....
75	399	116	152	188	224	261	297	333	....	....	....
80	413	124	163	201	240	279	318	....	....	....	....
85	425	131	172	213	254	295	....	....	....	....	....
90	438	139	182	225	269	312	....	....	....	....	...
95	449	146	191	236	282	327	....	....	....	....	....
100	461	153	201	248	295	....	....	....	....	....	....

2 1/2- AND 3-INCH HOSE.

ENGINE, WHILE STREAM IS FLOWING, TO MAINTAIN NOZZLE THROUGH VARIOUS LENGTHS OF BEST QUALITY RUBBER LINED HOSE.

Single 3-inch Lines.							Two 2½-inch Lines Siamesed.						Nozzle Pressure Indicated by Pitot Gage.
400 Feet.	600 Feet.	800 Feet.	1,000 Feet.	1,200 Feet.	1,500 Feet.	1,800 Feet.	600 Feet.	800 Feet.	1,000 Feet.	1,200 Feet.	1,500 Feet.	1,800 Feet.	
37	46	54	62	70	83	95	39	45	51	57	67	76	**20**
47	57	67	77	87	102	117	48	55	62	70	80	91	**25**
56	68	81	93	105	123	142	57	66	74	83	96	109	**30**
65	79	92	106	120	141	161	66	76	86	95	110	125	**35**
74	89	105	120	136	159	183	75	87	99	110	127	144	**40**
83	100	117	135	152	178	204	84	96	109	121	140	158	**45**
91	111	130	149	168	197	226	93	107	121	135	155	176	**50**
100	121	142	163	184	216	247	102	117	132	147	169	192	**55**
109	132	155	178	201	235	270	111	128	144	160	185	210	**60**
118	143	167	192	217	254	291	120	137	155	173	199	225	**65**
127	154	180	206	233	272	....	129	147	166	185	213	241	**70**
136	164	192	220	248	290	....	137	157	177	197	227	257	**75**
145	175	205	235	265	....	....	147	169	190	212	244	276	**80**
153	184	216	247	279	....	....	156	179	201	224	258	292	**85**
162	195	228	261	295	....	....	165	189	213	237	273	309	**90**
170	205	240	275	....	....	....	173	198	223	248	286	323	**95**
179	215	252	288	....	....	....	182	208	235	261	300	..	**100**

1 3/8-INCH SMOOTH NOZZLE.—

Nozzle Pressure Indicated by Pitot Gage.	Discharge, Gallons per Minute.	PRESSURES REQUIRED AT HYDRANT OR FIRE NOZZLE PRESSURES GIVEN IN FIRST QUALITY 2½- AND									
		Single 2½-inch Lines.									
		100 Feet.	200 Feet.	300 Feet.	400 Feet.	500 Feet.	600 Feet.	700 Feet.	800 Feet.	200 Feet.	400 Feet.
20	250	37	52	68	83	98	113	128	144	34	45
25	280	46	64	83	102	121	139	158	177	41	56
30	307	55	77	99	121	144	166	188	210	50	67
35	331	64	89	115	140	166	191	217	242	58	78
40	354	73	102	131	160	189	218	247	276	67	89
45	376	81	114	146	178	211	243	275	307	74	99
50	396	90	125	161	196	222	257	293	328	82	109
55	415	99	137	176	215	254	292	331	....	90	121
60	434	107	149	191	233	276	318	....	....	98	131
65	451	116	161	206	251	297	....	....	....	106	141
70	469	125	173	222	270	319	....	....	....	114	152
75	485	134	185	237	289	....	..	....	....	122	162
80	500	142	196	251	305	....	....	....	...	130	172
85	516	151	209	267	325	....	....	....	....	138	183
90	531	159	220	281	....	....	....	....	....	146	194
95	546	168	232	297	....	....	....	....	...	153	203
100	560	177	244	312	....	....	....	....	....	162	215

2 1/2- AND 3-INCH HOSE.

ENGINE, WHILE STREAM IS FLOWING, TO MAINTAIN COLUMN, THROUGH VARIOUS LENGTHS OF BEST 3-INCH RUBBER LINED HOSE.

Single 3-inch Lines.					Two 2½-inch Lines Siamesed.							Nozzle Pressure Indicated by Pitot Gage.
600 Feet.	800 Feet.	1,000 Feet.	1,200 Feet.	1,500 Feet.	400 Feet.	600 Feet.	800 Feet.	1,000 Feet.	1,200 Feet.	1,500 Feet.	1,800 Feet.	
57	68	80	92	109	37	46	54	63	71	84	96	20
70	85	99	113	135	46	57	67	78	88	104	119	25
84	101	118	135	161	56	68	81	93	106	124	143	30
97	117	137	157	187	65	80	94	108	122	143	165	35
112	134	157	180	214	74	90	106	122	138	162	186	40
125	150	175	200	238	83	101	119	137	155	182	209	45
137	164	192	220	267	92	111	131	151	171	201	230	50
151	182	212	242	288	100	122	144	165	187	219	252	55
163	196	229	262	....	109	133	156	180	203	238	273	60
177	212	247	282	...	118	143	168	194	219	257	294	65
189	227	265	303	....	128	155	182	209	236	277	317	70
203	243	283	....	....	137	165	194	223	252	295	....	75
215	257	300	..	....	145	175	206	236	266	312	....	80
229	274	....	....	....	153	186	218	250	282	331	....	85
241	289	....	....	....	162	196	230	264	298	....	....	90
254	304	....	....	....	170	206	241	277	313	..	....	95
267	....	....	....	....	179	217	254	291	329	....	....	100

1 1/2-INCH SMOOTH NOZZLE.—

Nozzle Pressure Indicated by Pitot Gage.	Discharge, Gallons per Minute.	PRESSURES REQUIRED AT HYDRANT OR FIRE NOZZLE PRESSURES GIVEN IN FIRST QUALITY 2½- AND										
		Single 2½-inch Lines.								Single		
		100 Feet.	200 Feet.	300 Feet.	400 Feet.	500 Feet.	600 Feet.	700 Feet.	800 Feet.	200 Feet.	400 Feet.	600 Feet.
20	298	44	65	86	107	128	149	170	191	39	55	71
25	333	54	80	106	132	158	184	210	236	48	68	88
30	365	65	95	126	157	188	219	250	280	58	81	105
35	394	75	110	145	181	216	251	287	322	67	94	122
40	422	85	126	166	206	246	286	327	....	76	107	139
45	447	96	141	185	230	275	320	....	....	85	120	155
50	472	106	155	205	254	304	....	....	....	95	133	171
55	494	116	170	224	278	332	....	....	....	104	145	187
60	517	126	184	242	301	....	....	....	....	113	158	203
65	537	136	198	261	324	....	....	....	....	122	170	218
70	558	146	213	281	....	....	....	....	....	131	183	235
75	578	156	228	299	....	....	....	....	....	140	196	251
80	596	166	242	318	....	....	....	....	....	149	208	267
85	614	176	257	337	....	....	....	....	....	158	220	282
90	633	187	272	....	....	....	....	....	....	167	233	298
95	650	197	286	....	....	....	....	....	....	176	245	314
100	667	207	300	....	....	....	....	....	....	185	257	...

2 1/2- AND 3-INCH HOSE.

ENGINE, WHILE STREAM IS FLOWING, TO MAINTAIN COLUMN, THROUGH VARIOUS LENGTHS OF BEST 3-INCH RUBBER LINED HOSE.												Nozzle Pressure Indicated by Pitot Gage.
3-inch Lines.				Two 2½-inch Lines Siamesed.								
800 Feet.	1,000 Feet.	1,200 Feet.	1,500 Feet.	200 Feet.	400 Feet.	600 Feet.	800 Feet.	1,000 Feet.	1,200 Feet.	1,500 Feet.	1,800 Feet.	
87	104	120	144	33	45	56	68	79	91	108	126	**20**
108	128	148	178	41	56	70	84	99	113	135	156	**25**
129	153	177	212	49	66	83	100	117	134	160	185	**30**
149	177	204	245	57	77	96	116	135	155	184	214	**35**
170	201	232	279	65	88	110	132	155	177	211	244	**40**
189	224	258	....	73	97	122	146	171	196	233	269	**45**
209	247	286	....	81	108	136	163	190	218	259	300	**50**
228	270	....	....	88	118	148	178	208	237	282	327	**55**
248	293	....	....	96	128	161	193	225	257	305	....	**60**
267	....	....	....	104	139	174	208	243	278	....	....	**65**
287	....	....	....	112	149	186	223	261	298	....	....	**70**
307	....	....	....	120	160	199	239	279	319	....	....	**75**
....	...	....	....	127	170	212	254	296	....	....	....	**80**
....	....	....	....	135	179	224	268	313	....	....	....	**85**
....	....	....	....	143	190	237	284	....	....	....	....	**90**
....	....	....	....	152	201	251	301	....	....	....	....	**95**
....	....	....	....	160	212	264	316	....	....	....	....	**100**

1 5/8-INCH SMOOTH NOZZLE.—

Nozzle Pressure Indicated by Pitot Gage.	Discharge, Gallons per Minute.	PRESSURES REQUIRED AT HYDRANT OR FIRE NOZZLE PRESSURES GIVEN IN FIRST QUALITY 2½- AND									
		Single 2½-inch Lines.						Single 3-inch			
		100 Feet.	200 Feet.	300 Feet.	400 Feet.	500 Feet.	600 Feet.	200 Feet.	400 Feet.	600 Feet.	800 Feet.
20	350	52	80	108	136	165	193	46	68	90	112
25	392	65	100	135	170	205	240	57	84	111	138
30	429	77	118	160	201	242	284	68	100	132	164
35	463	89	136	184	231	279	326	78	115	152	189
40	496	101	155	208	262	316	....	89	131	173	215
45	525	113	173	233	293	....	....	100	146	193	239
50	554	125	192	258	324	....	....	111	162	214	265
55	581	137	210	282	....	....	....	121	178	234	290
60	607	149	228	306	....	....	....	132	193	254	....
65	631	162	246	330	....	....	....	143	209	275	....
70	655	173	263	....	....	....	....	153	223	294	....
75	678	184	281	...	....	....	....	163	237	312	....
80	700	197	299	..	....	....	....	174	253	....	....
85	722	209	317	....	....	....	....	184	269	....	....
90	743	220	....	....	....	....	....	195	284	....	....
		232	....	....	....	....	....	205	299	....	....
		[illegible]	....	....	....	....	....	216	314	....	....

2 1/2- AND 3-INCH HOSE,

ENGINE, WHILE STREAM IS FLOWING, TO MAINTAIN COLUMN, THROUGH VARIOUS LENGTHS OF BEST 3-INCH RUBBER LINED HOSE.										Nozzle Pressure Indicated by Pitot Gage.
Lines.		Two 2½-inch Lines Siamesed.								
1,000 Feet.	1,200 Feet.	200 Feet.	400 Feet.	600 Feet.	800 Feet.	1,000 Feet.	1,200 Feet.	1,500 Feet.	1,800 Feet.	
134	156	37	53	68	84	100	115	139	162	20
165	192	47	66	85	104	123	143	171	200	25
196	228	56	79	102	125	148	171	205	240	30
226	263	65	91	117	144	170	197	236	276	35
257	299	74	104	134	164	194	224	269	314	40
286	....	82	116	149	182	215	248	298	....	45
....	....	91	128	165	202	239	275	331	....	50
....	....	100	140	181	221	261	301	....	....	55
....	....	109	153	196	240	283	327	....	....	60
....	....	118	164	211	258	305	....	....	....	65
....	....	126	176	226	276	326	....	....	....	70
....	....	135	189	242	295	....	....	....	....	75
....	....	144	201	258	314	....	....	....	....	80
....	....	153	213	273	....	....	....	....	....	85
....	....	162	225	289	....	....	....	....	....	90
....	....	170	237	303	....	....	....	....	....	95
....	....	179	249	319	....	....	....	....	....	100

1 3/4-INCH SMOOTH NOZZLE.—

Nozzle Pressure Indicated by Pitot Gage.	Discharge Gallons per Minute.	PRESSURES REQUIRED AT HYDRANT OR FIRE NOZZLE PRESSURES GIVEN IN FIRST QUALITY 2½- AND									
		Single 2½-in. Lines.				Single 3-inch					
		100 Feet.	200 Feet.	300 Feet.	400 Feet.	100 Feet.	200 Feet.	300 Feet.	400 Feet.	500 Feet.	600 Feet.
20	407	63	100	138	175	40	55	71	86	101	116
25	455	77	123	169	215	49	67	84	102	120	138
30	498	91	145	199	253	58	79	100	121	142	163
35	538	106	169	231	294	68	92	117	141	166	190
40	575	120	191	262	333	77	104	132	159	187	215
45	609	135	215	294	....	87	118	149	180	211	241
50	643	150	237	325	....	96	130	164	199	233	267
55	674	164	259	....	....	105	142	179	216	254	291
60	704	177	280	....	....	114	154	194	234	274	314
65	732	191	302	....	....	123	166	209	252	296	....
70	761	206	325	....	...	133	180	227	273	....	....
75	787	220	....	....	....	143	192	242	291	....	....
80	813	234	....	....	...	152	204	257	309	....	....
85	838	247	....	....	....	160	215	270	....	....	....
90	862	261	....	....	....	169	228	286	....	....	....
95	885	274	....	....	....	178	240	301	....	....	....
100	909	....	....	....	....	188	253	317	....	...	....

2 1/2- AND 3-INCH HOSE.

ENGINE, WHILE STREAM IS FLOWING, TO MAINTAIN COLUMN, THROUGH VARIOUS LENGTHS OF BEST 3-INCH RUBBER LINED HOSE.											Nozzle Pressure Indicated by Pitot Gage.
Lines.		Two 2½-inch Lines Siamesed.									
800 Feet.	1,000 Feet.	100 Feet.	200 Feet.	300 Feet.	400 Feet.	500 Feet.	600 Feet.	800 Feet.	1,000 Feet.	1,200 Feet.	
147	177	33	43	53	64	74	84	105	125	146	20
173	209	40	53	65	78	91	103	128	154	179	25
205	247	49	64	79	94	110	125	155	185	215	30
239	288	56	74	91	109	126	143	178	213	248	35
270	325	64	84	103	123	143	162	201	241	280	40
303	....	73	95	117	139	161	183	227	271	315	45
....	....	80	104	128	152	177	201	249	297	....	50
....	....	88	114	140	167	193	219	272	324	....	55
....	....	96	125	153	182	210	239	296	....	....	60
....	....	104	134	165	195	226	257	318	....	....	65
....	....	111	144	177	210	243	275	....	....	....	70
...	....	118	153	188	223	258	293	....	....	....	75
....	....	127	164	201	239	276	313	....	...	....	80
....	....	135	174	214	253	293	....	....	....	....	85
....	....	142	183	225	266	308	....	....	....	....	90
....	....	150	194	237	281	....	....	....	....	....	95
....	....	158	204	250	296	....	....	....	....	....	100

2-INCH SMOOTH NOZZLE.—

Nozzle Pressure Indicated by Pitot Gage.	Discharge, Gallons per Minute.	PRESSURES REQUIRED AT HYDRANT OR FIRE NOZZLE PRESSURES GIVEN IN FIRST QUALITY 2½- AND							
		Single 2½-inch Lines.			Single 3-inch Lines.				
		100 Feet.	200 Feet.	300 Feet.	100 Feet.	200 Feet.	300 Feet.	400 Feet.	500 Feet.
20	532	90	152	214	52	76	100	124	148
25	594	111	187	263	65	94	123	152	182
30	651	132	222	312	77	112	147	181	216
35	703	152	255	.....	89	129	169	209	249
40	752	173	290	.....	102	147	193	238	283
45	797	193	323	....	113	163	213	263	314
50	841	214	.....	.....	126	182	237	293	.....
55	881	.....	.....	.....	138	199	260	321	.....
60	920	.....	.....	.....	150	216	282	.....	.....
65	958	.....	.....	.....	162	233	304	.....	.....
70	994	.....	.....	.....	175	251	327	.....	.....
75	1,029	.....	.....	.....	187	268	.....	.....	.....
80	1 063	....	.....	.....	199	285	.....	.....	.....
85	1,095	.....	.....	.....	211	302	.....	.....	.....
90	1,128	.....	.....	.....	223	319	.....	.....	.....
95	1,158	.....	.....	.....	235	335	.....	....	....
100	1,189	.....	....	....	247	.....	.....	.....	.....

2 1/2- AND 3-INCH HOSE.

ENGINE, WHILE STREAM IS FLOWING, TO MAINTAIN COLUMN, THROUGH VARIOUS LENGTHS OF BEST 3-INCH RUBBER LINED HOSE.

		Two 2½-inch Lines Siamesed.								Nozzle Pressure Indicated by Pitot Gage.
600 Feet.	800 Feet.	100 Feet.	200 Feet.	300 Feet.	400 Feet.	500 Feet.	600 Feet.	800 Feet.	1,000 Feet.	
172	220	41	58	75	92	110	127	161	195	**20**
211	270	51	72	93	114	135	156	198	240	**25**
251	321	61	86	110	135	160	185	234	284	**30**
289	.....	71	100	128	157	186	214	271	329	**35**
.....	.....	81	113	146	178	211	243	308	.....	**40**
.....	.....	90	126	162	198	234	270	.....	.....	**45**
.....	.....	100	140	180	220	260	300	.....	.....	**50**
.....	.....	110	153	197	240	284	.....	.....	.....	**55**
.....	.....	119	166	213	260	308	.....	.....	.....	**60**
.....	.....	129	180	230	281	.....	.....	.....	.....	**65**
.....	.....	139	193	248	302	.....	.....	.....	.....	**70**
.....	.....	148	206	264	322	.....	.....	.....	.....	**75**
.....	.....	158	219	280	.....	.....	.....	.....	.....	**80**
.....	.....	167	232	297	.....	.....	.....	.....	.....	**85**
.....	.....	177	245	314	.....	.....	.....	.....	.....	**90**
.....	.....	186	258	.....	.....	.....	.....	.....	.....	**95**
.....	.....	196	272	.....	.....	.....	.....	.....	.....	**100**

1 1/4-INCH SMOOTH NOZZLE.—3 1/2-INCH HOSE.

Nozzle Pressure Indicated by Pitot Gage.	Discharge, Gallons per Minute.	Pressures Required at Hydrant or Fire Engine, while Stream is Flowing, to Maintain Nozzle Pressures given in First Column, through various Lengths of Best Quality 3½-inch Rubber Lined Hose.								Nozzle Pressure Indicated by Pitot Gage.
		600 Feet.	700 Feet.	800 Feet.	900 Feet.	1,000 Feet.	1,200 Feet.	1,500 Feet.	1,800 Feet.	
20	206	32	34	36	37	39	43	49	55	**20**
25	230	39	42	44	46	48	53	60	67	**25**
30	253	47	49	52	55	58	63	71	79	**30**
35	273	54	57	60	64	67	73	82	91	**35**
40	292	62	65	69	72	76	83	93	104	**40**
45	309	69	73	77	81	85	93	104	116	**45**
50	326	77	81	85	90	94	102	115	128	**50**
55	342	84	89	94	99	103	112	126	141	**55**
60	357	92	97	102	107	112	122	137	153	**60**
65	372	99	105	110	116	121	132	149	165	**65**
70	386	107	113	118	124	130	142	160	177	**70**
75	399	114	120	127	133	139	152	171	190	**75**
80	413	122	128	135	142	148	162	182	202	**80**
85	425	128	135	142	149	156	170	191	212	**85**
90	438	136	143	151	158	165	180	202	225	**90**
95	449	143	151	159	167	175	190	214	237	**95**
100	461	151	159	167	175	184	200	225	249	**100**

1 3/8-INCH SMOOTH NOZZLE.—3 1/2-INCH HOSE.

Nozzle Pressure Indicated by Pitot Gage.	Discharge, Gallons per Minute.	PRESSURES REQUIRED AT HYDRANT OR FIRE ENGINE, WHILE STREAM IS FLOWING, TO MAINTAIN NOZZLE PRESSURES GIVEN IN FIRST COLUMN, THROUGH VARIOUS LENGTHS OF BEST QUALITY 3½-INCH RUBBER LINED HOSE.									Nozzle Pressure Indicated by Pitot Gage.
		400 Feet.	500 Feet.	600 Feet.	700 Feet.	800 Feet.	1,000 Feet.	1,200 Feet.	1,500 Feet.	1,800 Feet.	
20	250	31	34	36	39	41	47	52	60	67	**20**
25	280	39	42	45	49	52	59	65	75	85	**25**
30	307	46	50	54	58	62	70	78	89	101	**30**
35	331	54	58	63	67	72	81	90	103	117	**35**
40	354	61	66	71	76	81	91	101	116	131	**40**
45	376	69	74	80	85	91	102	113	130	147	**45**
50	396	76	82	88	95	101	113	126	144	163	**50**
55	415	84	90	97	104	111	124	138	158	179	**55**
60	434	91	98	106	113	121	135	150	172	195	**60**
65	451	98	106	114	122	130	146	161	185	209	**65**
70	469	106	114	123	131	140	157	174	199	225	**70**
75	485	113	122	131	140	149	167	185	212	239	**75**
80	500	120	130	140	149	159	178	197	226	255	**80**
85	516	127	138	148	158	168	188	208	239	269	**85**
90	531	135	146	156	167	178	199	221	253	285	**90**
95	546	142	153	165	176	187	209	232	266	299	**95**
100	560	150	161	173	185	197	220	244	279	315	**100**

1 1/2-INCH SMOOTH NOZZLE.—3 1/2-INCH HOSE.

Nozzle Pressure Indicated by Pitot Gage.	Discharge, Gallons per Minute.	PRESSURES REQUIRED AT HYDRANT OR FIRE ENGINE, WHILE STREAM IS FLOWING, TO MAINTAIN NOZZLE PRESSURES GIVEN IN FIRST COLUMN, THROUGH VARIOUS LENGTHS OF BEST QUALITY 3½-INCH RUBBER LINED HOSE.								Nozzle Pressure Indicated by Pitot Gage.
		200 Feet.	400 Feet.	600 Feet.	800 Feet.	1,000 Feet.	1,200 Feet.	1,500 Feet.	1,800 Feet.	
20	298	28	36	43	50	58	65	76	87	**20**
25	333	35	44	53	62	71	80	93	107	**25**
30	365	42	53	63	74	85	96	112	128	**30**
35	394	49	61	73	86	98	111	129	148	**35**
40	422	55	69	83	97	111	125	146	167	**40**
45	447	62	78	93	109	125	140	164	187	**45**
50	472	69	86	103	121	138	155	181	207	**50**
55	494	76	94	113	132	151	170	198	226	**55**
60	517	82	102	123	143	163	183	214	244	**60**
65	537	89	111	133	154	176	198	231	263	**65**
70	558	96	119	143	166	189	213	248	283	**70**
75	578	103	128	153	178	203	228	265	303	**75**
80	596	109	136	162	188	215	241	281	....	**80**
85	614	116	144	172	200	228	256	298	....	**85**
90	633	123	152	182	211	241	271	....	....	**90**
95	650	129	160	191	222	253	284	....	....	**95**
100	667	136	168	201	233	265	298	....	....	**100**

1 5/8-INCH SMOOTH NOZZLE.—3 1/2-INCH HOSE.

Nozzle Pressure Indicated by Pitot Gage.	Discharge, Gallons per Minute.	PRESSURES REQUIRED AT HYDRANT OR FIRE ENGINE, WHILE STREAM IS FLOWING, TO MAINTAIN NOZZLE PRESSURES GIVEN IN FIRST COLUMN, THROUGH VARIOUS LENGTHS OF BEST QUALITY 3½-INCH RUBBER LINED HOSE.								Nozzle Pressure Indicated by Pitot Gage.
		200 Feet.	400 Feet.	600 Feet.	800 Feet.	1,000 Feet.	1,200 Feet.	1,500 Feet.	1,800 Feet.	
20	350	31	41	50	60	70	80	94	109	**20**
25	392	38	51	63	75	87	99	118	136	**25**
30	429	46	60	75	89	103	118	139	161	**30**
35	463	53	70	86	103	120	136	161	186	**35**
40	496	61	79	98	117	136	155	183	211	**40**
45	525	68	89	110	131	152	173	205	236	**45**
50	554	76	99	122	145	168	192	226	261	**50**
55	581	83	108	133	158	184	209	247	284	**55**
60	607	90	117	144	172	199	226	267	308	**60**
65	631	97	127	156	186	215	244	289	...	**65**
70	655	105	136	167	199	230	262	309	....	**70**
75	678	112	145	179	212	245	279	....	....	**75**
80	700	119	155	191	226	262	297	....	....	**80**
85	722	127	165	202	240	278	316	....	....	**85**
90	743	134	174	214	254	294	....	....	....	**90**
95	763	141	183	225	267	309	....	....	....	**95**
100	783	149	193	237	281	..	....	....	....	**100**

1 3/4-INCH SMOOTH NOZZLE.—3 1/2-INCH HOSE.

Nozzle Pressure Indicated by Pitot Gage.	Discharge, Gallons per Minute.	PRESSURES REQUIRED AT HYDRANT OR FIRE ENGINE, WHILE STREAM IS FLOWING, TO MAINTAIN NOZZLE PRESSURES GIVEN IN FIRST COLUMN, THROUGH VARIOUS LENGTHS OF BEST QUALITY 3½-INCH RUBBER LINED HOSE.									Nozzle Pressure Indicated by Pitot Gage.
		100 Feet.	200 Feet.	300 Feet.	400 Feet.	500 Feet.	600 Feet.	800 Feet.	1,000 Feet.	1,200 Feet.	
20	407	28	35	41	48	54	61	74	87	101	**20**
25	455	35	43	51	59	67	75	91	107	123	**25**
30	498	41	51	60	70	79	89	108	127	146	**30**
35	538	48	59	70	81	92	103	124	146	168	**35**
40	575	55	67	80	92	105	117	142	167	191	**40**
45	609	62	75	89	103	117	131	158	186	213	**45**
50	643	68	84	99	115	130	145	176	206	237	**50**
55	674	75	92	109	125	142	159	192	225	259	**55**
60	704	82	100	118	136	154	172	208	244	280	**60**
65	732	89	108	127	147	166	186	224	263	302	**65**
70	761	95	116	137	158	178	199	241	282	....	**70**
75	787	102	124	146	168	190	212	257	301	....	**75**
80	813	109	132	156	179	203	226	273	320	....	**80**
85	838	115	140	165	190	214	239	289	....	....	**85**
90	862	122	148	174	200	227	253	305	....	....	**90**
95	885	128	156	183	211	238	266	....	....	....	**95**
100	909	135	164	193	222	251	280	....	....	....	**100**

2-INCH SMOOTH NOZZLE.—3 1/2-INCH HOSE.

Nozzle Pressure Indicated by Pitot Gage.	Discharge, Gallons per Minute.	PRESSURES REQUIRED AT HYDRANT OR FIRE ENGINE, WHILE STREAM IS FLOWING, TO MAINTAIN NOZZLE PRESSURES GIVEN IN FIRST COLUMN, THROUGH VARIOUS LENGTHS OF BEST QUALITY 3½-INCH RUBBER LINED HOSE.								Nozzle Pressure Indicated by Pitot Gage.
		100 Feet.	200 Feet.	300 Feet.	400 Feet.	500 Feet.	600 Feet.	800 Feet.	1,000 Feet.	
20	532	33	44	55	65	76	87	109	130	**20**
25	594	41	54	67	80	93	106	133	159	**25**
30	651	49	64	80	96	111	127	158	189	**30**
35	703	57	75	93	111	129	147	183	219	**35**
40	752	65	85	105	126	146	166	207	247	**40**
45	797	72	95	118	140	163	185	231	276	**45**
50	841	80	105	130	155	180	205	255	305	**50**
55	881	88	116	143	170	197	225	279	....	**55**
60	920	96	126	155	185	214	244	303	...	**60**
65	958	104	136	168	200	232	263	....	....	**65**
70	994	112	146	180	214	248	282	....	....	**70**
75	1,029	119	156	192	229	265	301	....	....	**75**
80	1,063	127	166	205	243	282	....	..	....	**80**
85	1,095	135	176	217	258	299	...	....	....	**85**
90	1,128	143	186	229	272	....	....	....	....	**90**
95	1,158	151	196	241	286	....	....	....	....	**95**
100	1,189	158	206	253	301	....	....	..	...	**100**

Gallons per Minute	NOZZLE PRESSURE, POUNDS				FRICTION LOSS IN HOSE, POUNDS PER 100 FEET							
	DIAMETER OF TIP				LINEN HOSE				RUBBER OR RUBBER-LINED HOSE			
	1/2"	5/8"	3/4"	7/8"	1 1/4"	1 1/2"	2"	2 1/2"	3/4"	1"	1 1/2"	2"
10	1.8				2.5	1.			13.5	3.5	0.5	0.1
15	4.1				5.2	2.2			29.	7.2	1.0	0.3
20	7.3				9.	3.6			50.	12.3	1.7	0.4
25	11.5	4.6			13.4	5.5			75.	18.5	2.6	0.6
30	16.5	6.6			18.6	8.	1.9		105.	26.	3.6	0.9
35	22.5	8.9	4.4		25.	10.	2.5		140.	35.	4.8	1.2
40	29.4	11.7	5.7		32.	13.	3.2		180.	44.	6.1	1.5
45	37.2	14.8	7.2		40.	16	4.0		222.	55.	7.6	1.9
50	45.8	18.3	8.9	4.8	48.	20.	4.9	1.6	270.	67.	9.3	2.3
70		36.	17.5	9.5	90.	37.	9.	3.1			17.	4.3
100		73.	35.6	19.3	174.	72.	17.5	5.9			33.	8.4
120			51.	27.8			25.	8.3			47.	1.7
150			80.	43.5			37.	12.5			71.	18.0
170				56.			47.	15.8			89.	22.7
200				77.			63.	21.5			121.	30.6
250								22.			182.	46.0

METHODS OF DETERMINING APPROXIMATE NOZZLE OR ENGINE PRESSURES WITH HOSE LINES MADE UP OF TWO DIFFERENT SIZES OF HOSE, SIAMESED LINES OR A SINGLE LINE BRANCHING INTO TWO

A fairly common form of example in hose layouts is one involving siamesed lines, or a line made up of two different sizes of hose. These can be worked easiest by reducing the siamesed lines, or the different sizes of hose all to an equivalent length of 2½-inch hose that is, to a length of 2½-inch hose which will give the same total friction loss as the siamesed line or the combined lines. To enable this to be done, the factors on page 695, based upon the relative friction loss of the different sizes and combination of hose, can be used.

For an example indicating the use of the factors: From a high pressure hydrant, one 400-foot line of 2½-inch hose and one 400-foot line of 3-inch hose is siamesed into a 600-foot line of 3-inch hose, which connects to a 400-foot line of 2½-inch hose having a 1¼-inch tip; what pressure will be necessary at the hydrant to give 50 pounds nozzle pressure?

The factor for siamesed lines of 3-inch and 2½-inch is 6.1; then the length of 2½-inch hose equivalent to the 400 feet of siamesed lines is $\frac{400}{6.1}$, or 65 feet.

The factor for 3-inch hose is 2.6; then the length of 2½-inch hose equivalent to the 600 feet of 3-inch is $\frac{600}{2.6}$, or 230 feet.

Therefore the total equivalent 2½-inch line is 65 plus 230 plus 400 feet, or 695 feet, which can be assumed as 14 lengths.

Using the constant (K) for 1¼-inch nozzle, as given on page 697, we can solve the problem with ease, as follows:

$$\begin{aligned}\text{Engine Pressure} &= 50\ (1.1 + .246 \times 14)\\ &= 50\ (1.1 + 3.47)\\ &= 50 \times 4.57\\ &= 228 \text{ pounds}\end{aligned}$$

For siamesed lines of hose of same diameter, but of different length, the following rules may be used:

Siamesed line, one twice as long as the other, equal one line one-third the length of the shortest.

Example: One line 300 feet and one line 600 feet siamesed, are equal to one line 100 feet long.

Siamesed lines, one three times as long as the other, equal one line 0.4 the length of the shortest.

Example: One line 500 feet and one line 1,500 feet siamesed are equal to one line 0.4 × 500, or 200 feet long.

For the problem involving a single line of hose branching into two lines, each with a separate nozzle, it is necessary to find the length of a single line having the same friction loss as the two parallel lines, and the size of a single nozzle equivalent to the two on the lines in question. Equivalent nozzle sizes may be taken from the table on page 727 and the equivalent length of a single line may be found by the use of the factors given in the preceding problem.

It is not always possible to find a nozzle size, for use in the formula on page 697, which is the exact equivalent of two or more smaller nozzles, but a close approximation can usually be made or a value of K for an odd size can be calculated as given at the bottom of page 697.

For an example indicating the method of working out this problem, consider a single 500-foot line of 3-inch hose branching into two 300-foot lines of 2½-inch hose, each with a 1⅛-inch nozzle. Assume a pressure of 150 pounds at the engine and determine the nozzle pressure.

Two 1⅛-inch nozzles are approximately the equivalent of one 1⅝-inch nozzle.

The factor of 3-inch hose is 2.6, and the length of 2½-inch hose equivalent to 500 feet of 3-inch is $\frac{500}{2.6}$ or 192 feet.

The factor for two lines of 2½-inch hose is 3.6, and the length of a single line of 2½-inch hose equivalent to two 300-foot lines is $\frac{300}{3.6}$ or 83 feet.

This combination of hose and nozzles is, therefore, the equivalent, that is, will deliver about the same amount of water, as one 1⅝-inch nozzle on the end of a line of 2½-inch hose, 192 + 83 feet long = 275 feet. Using the formula on page 700, we have then:

$$\text{Nozzle Pressure} = \frac{150}{1.1 + 5.5 \times 0.68} = 31 \text{ pounds}$$

By using the table on page 700 to determine the discharge at 31 pounds nozzle pressure through a 1⅛-inch nozzle, and table on page 699 to determine the friction loss in 500 feet of 3-inch hose and two 300-foot lines of 2½-inch hose, we find that the solution is not exactly correct, since the 31 pounds nozzle pressure in the problem above will actually require, allowing about 3 pounds loss at the engine outlet and the same at the Y branch, only 146 pounds engine pressure. The error in this case arises from the fact that the two 1⅛-inch nozzles are not quite the equivalent of one 1⅝-inch. The solution of the problem given above is, however, sufficiently close for all practical purposes.

APPROXIMATE COMPARISON OF NOZZLES

Number of Nozzles

1	5-8"	3-4"	7-8"	1"	1 1-8"	1 1-4"	1 3-8"	1 1-2"	1 5-8"	1 3-4"	1 7-8"	2"
2	7/8"	1 1/16"	1 1/4"	1 3/8"	1 5/8"	1 3/4"	1 15/16"	2 1/8"	2 5/16"	2 1/2"	2 5/8	2 13/16"
3	1 1/16"	1 5/16"	1 1/2"	1 3/4"	1 15/16"	2 3/16"	2 3/8"	2 5/8"	2 13/16"	3"	3 1/4"	3 1/2"
4	1 1/4"	1 1/2"	1 3/4"	2"	2 1/4"	2 1/2"	2 3/4"	3"	3 1/4"	3 1/2"	3 3/4"	4"
5	1 3/8"	1 11/16"	2"	2 1/4"	2 1/2"	2 3/4"	3 1/16"	3 3/8"	3 5/8"	3 15/16"	4 3/16"	
6	1 1/2"	1 13/16"	2 1/8"	2 7/16"	2 3/4"	3 1/16"	3 3/8"	3 11/16"	4"			
7	1 5/8"	2"	2 5/16"	2 5/8"	3"	3 5/16"	3 5/8"	4"				
8	1 3/4"	2 1/8"	2 1/2"	2 13/16"	3 3/16"	3 9/16"	3 7/8"					
9	1 7/8"	2 1/4"	2 5/8"	3"	3 3/8"	3 3/4"	4 1/8"					
10	2"	2 3/8"	2 3/4"	3 3/16"	3 9/16"	4"						
11	2 1/16"	2 1/2"	2 7/8"	3 5/16"	3 3/4"							
12	2 3/16"	2 5/8"	3"	3 1/2"	3 15/16"							

Method of Using.—To find which size nozzle equals two 1⅛-inch nozzles: On the line marked 2, the size nozzle (1⅝) in the column 1⅛" will be the corresponding size.

INSPECTION REPORTS

Below is presented an address by F. C. White, Executive Assistant of the New York Underwriters Agency, before the Fire Underwriters Uniformity Association, which deals with the subject in a practical manner, with particular reference to what the Fire Insurance Companies expect a report to cover.

A Complex Subject.—The subject, "What the Companies Expect from Inspection Reports," is so important, and in a sense so complex, that while I was glad to accept the invitation of your president to speak on it, believing that by so doing I might assist in the good work you are undertaking, I approached the task with considerable diffidence.

In preparing the subject matter for this paper I have endeavored to give a general idea of all companies' needs in the matter of inspection reports, based upon such data as I have been able to gather in the limited time at my disposal, rather than to confine myself to an expression of purely personal convictions.

One point respecting inspection reports upon which all companies are agreed is the urgent need of uniformity. The importance of this phase of the subject under consideration is sufficient to warrant serious thought, and leads me to devote some time to it before taking up other details.

Varying Reports Costly.—Lack of uniformity in inspection reports is, in my belief, not only costly to the companies by reason of the additional length of time required to pass upon them, but is also the direct cause of loss of business, or overlines, from quite natural misconceptions on the part of examiners. To illustrate my meaning let me give you some statistics from our own office, statistics which are duplicated, or approximated, in the offices of all companies doing a country-wide business. Through our Special Risk Department we handle, in round numbers, 60,000 inspection reports per annum. Our agency departments pass nearly 20,000 more. All of these reports must be read. They come to us from thirty inspection bureaus and rating organizations, and each differs from the others to a greater or less degree. Now consider for a moment the mental agility required of the men whose duty it is to read and analyze these differing reports. First comes a report with a summary epitomized to the last safe degree, prominently set forth on the first page. An ideal condition. Next, one with the summary on the last page, and then one with no summary at all. One report covering twenty buildings in a plant, and then twelve reports covering twelve buildings in another plant, including separate reports for the dry kiln and oil house. One report giving the grading as a sprinklered risk "97.8 per cent," the next "7-10ths of the standard," and the next "good to fair." I had before me a few days ago two reports from different bureaus covering the same risk. One gave the sprinkler equipment a grading of 95 per cent, the other credited it with 44.4 per cent. Compiled as they were in acordance with the system in vogue in each bureau, both gradings were probably correct. To continue, one bureau gives a loss estimate in plain figures, substantiated by a statement of values. A report from another bureau gives no statement of values but does contain the opinion, if we may call it an opinion, "Prefer to believe that the fire department would effect a saving of 15 per cent." The examiner works his way through the reports as best he can, at times using his knowledge of the men responsible for them in attempting to estimate what effect the weather conditions may have had upon the expressed opinions, and in other cases heartened by the knowledge that he is dealing with facts, set down in the order of greatest importance, and in the plainest language. There can be no doubt that many mistakes would be obviated if all information reached the companies in uniform reports. Your association has done much toward bringing about this result. The service of those bureaus which have adopted the uniform report blank is most valuable to their subscribers, and the value of that service will increase as the scope of the reports is broadened (always uniformly, I hope), to cover all details that may be reasonably desired.

Proper Reports.—Now passing on to the question of the proper substance and extent of inspection reports, we may say, speaking broadly, that the companies want in each original report every fact that has any bearing on the intelligent underwriting of the risk reported on; and in each succeeding report they want a condensed statement of such facts brought down to date. There is without doubt a difference of opinion among companies on the question of what constitutes a proper report, but I am sure a careful analysis of the difference would show that it lies more in the form in which the facts should be set forth, than in the extent of the information needed. In my judgment the form of an ideal report blank would vary little, if any, from the blank adopted as the standard of this association. I am sure all companies would be well satisfied if every report contained just the information required to make a complete story under all heads provided in that blank, with perhaps a very slight amplification of which I shall speak later. To illustrate my conclusions as regards the difference of opinion among companies in respect to inspection reports, we will divide the companies into two general classes.

Conservative Special Hazard Writers.—In the first class we will put the companies that accept lines on special hazards and sprinklered risks conservatively, and maintain no special departments to handle those classes. I find that in their offices inspection reports are usually passed by the regular examiners, who also pass daily reports for all classes. These men have a great many details to handle and usually read inspection reports for only such risks as their companies have lines upon. The liability assumed on each risk is comparatively light, so a careful analysis of distribution of values and other details is not deemed a vital necessity. In fact, I find that in some offices it is the practice to "make assurance doubly sure" by discounting inspection bureau loss estimates as much as 50 per cent in fixing lines. Now these companies value inspection service, but you will readily understand that to be obliged to read a multitude of details in reports would, under their system of handling the business, be burdensome. For them, the summary that prefaces the standard uniform report would seem to be ideal.

Companies Writing Special Hazards Freely.—The second class comprises those companies that specialize on sprinklered risks, traction properties, and other large line special hazards. This business they handle through special departments, and they desire that inspection reports be complete in all details of construction, fire protection, hazards, distribution of values, etc. The reason for this I think you all understand very well. The lines written are usually large, and the acceptance of them involves great responsibility, which can be safely assumed only with a full knowledge of all conditions. No inspection bureau or rating organization can properly perform the underwriting functions of these companies, nor would it be fair to expect such service from them.

Uniform Blank Meets All Requirements.—So we have the two classes of companies that must be served through the same form of report: one desiring a sort of arctic explorer's tabloid meal, the other with members whose appetites can be appeased only by a complete collection of details. Both classes can be satisfied by a faithful observance of all requirements of the uniform report blank. The information provided in the condensed summary can be set forth only after collecting the details necessary for the complete report, and then boiling them down. The details once obtained may be incorporated in the report without serious expense, for the use of those who claim to need them.

Extent of Information Desired.—First repeating my belief that the standard uniform report blank, with a few minor additions, will furnish all information that any company needs, provided that all of its requirements are observed, I will refer as briefly as possible, to the extent of the information required under some of the principal heads of that blank, giving you such thoughts as have occurred to me, or have been suggested by those gentlemen with whom I have taken occasion to confer on the subject. The first head to which reference need be made is

Name of Broker.—Not all reports give information on this point, which by the companies is considered an important one. It is usually not difficult to obtain the name of broker or agent who carries the most of the insurance or places the line.

Map or Plan.—The companies which make a specialty of the classes of risks reported on by inspection bureaus value the plans which some bureaus furnish with reports on sprinklered risks, and would like to see the practice of sending out such plans made universal. The plans should be complete and uniform.

Raw Stock.—A complete list of materials should appear in each report. It requires trained inspectors to know what to look for in each risk. The importance of the information can hardly be overestimated.

Processes.—This is also a very important subject, and the remarks just made apply equally to it.

Machinery.—Under this head should be brought out any conditions that would have a bearing in classifying the risk. For example, cards in a woolen mill using some cotton stock should be described so that it may be known whether cotton is being worked on open wool cards or otherwise. On the other hand, full lists of machinery in such risks as machine shops, sash, door and blind factories, etc., are of minor importance. The presence of any special machinery should always be noted.

Location of Values.—Fully appreciating that it is very often difficult to gather information under this head, I cannot state too emphatically that it is highly important that every report contain a statement of values, even though it be obtained at the expense of much effort.

Prominently Desirable Features and Prominently Undesirable Features.—Full information under these heads affords the quickest means of analyzing a risk, and is one of the first things looked for in making an estimate. In some cases the undesirable features are so serious that a decision to decline the risk may be arrived at without reading further.

Construction.—Information should be full and complete, as provided for in the uniform report blank. Reports should give the percentage of each type of construction, and any unusual conditions should be brought out.

Common Hazards and Special Hazards.—Here again the trained inspector has opportunity to point out any unusual hazards, chemical combinations, etc. The description of all hazards should be made complete in all essential details.

Administration.—The importance of the information under this head is appreciated by all who examine inspection reports. It is one of the subjects turned to first in reports which contain the information. A succession of reports showing lax administration is usually sufficient warrant for declining the risk.

Exposure.—Information should be full and complete in accordance with the requirements of the uniform report blank. Lines cannot be fixed intelligently without a full knowledge of the exposures and the protection against same. Here again I would emphasize the necessity for facts, rather than opinions unsubstantiated by details.

Protection.—All details provided for in the uniform report blank are essential. The size of the street main and the static water pressure may mean very little without a statement of what is back of them. A full knowledge of public fire defenses cannot be had without making working tests. Some of our bureaus include an analysis of the town fire protection in their reports, and the facts brought out through their work are highly important. The value of street main connections to yard hydrants and sprinkler equipments cannot be determined accurately without such analysis.

Automatic Sprinkler Equipment.—Nothing short of a full statement in accordance with the requirements of the uniform report blank would be sufficient under this important head. It should be borne in mind that most companies desire all details regarding sprinkler equipments, even though some of them may impress the compiler of the reports as being immaterial. Reference to sprinkler alarms or other devices may not properly be omitted from reports because in the opinion of the author of the reports they are so fallible as to merit no mention. The reports in this respect, as well as all others, should consist of statements of facts, and should not contain opinions which find expression in the omission of what may by some be considered important details. By this is not meant to suggest the omission of definitely expressed opinions, so long as they are not substituted for facts. The last of the subheads for this subject in the uniform report blank reads:

Equipment in General.—Here the inspector has opportunity to cover much information of importance. Every inspection of a sprinkler equipment should include a careful examination of the tanks and their supports, including bearing walls. The hoops should be examined for deterioration, and any rotting of supports, or settling or cracking of walls, should be noticed in reports, and the attention of the insured should be drawn to same before the inspector leaves the premises. The companies encourage the installation of sprinklers, and they owe it to the insured to advise them on such points even though the companies might not suffer directly through a failure to do so. For the same reason the inspector should also report on any improperly heated sections of buildings, improperly insulated piping, or dry valve closets. He should report on any poorly supported piping, or sections of equipment subject to injury by settling of buildings, or dangerous proximity of belts to sprinklers, or any arrangement of stock piles that might endanger sprinkler risers or piping. In fact, every defect in the sprinkler equipment should be reported, and pointed out to the insured, even though such defects might not, in the inspector's opinion, seriously threaten the integrity of the sprinkler protection.

Record of Fires.—This is important information, and should be brought down to date in each succeeding report.

Improvements Recommended.—Recommendations covering vital improvements should be separated in reports from suggestions for improvements to make risks standard. I believe it is the general opinion that a proper function of all inspection bureaus is to bring about improvements in risks they inspect. It is important that vital defects be corrected whenever possible before the inspector leaves the risk. When this cannot be accomplished, the companies should be furnished reports of progress at short intervals, until improvements have been completed, or abandoned. The foregoing is the practice of some of our bureaus, and I believe the companies would willingly assume such additional expense as might be occasioned through the extension of the practice to all of them.

Reinspection Reports.—And now for the reinspection report. I will take up but a moment on this subject. The information required under the uniform reinspection blank with slight additions, should, I believe, satisfy all companies, but nothing short of that would suffice. At first glance it might seem unnecessary to repeat in the reinspection reports the information given in the original reports, but doing so would result in a saving of time to the companies more than sufficient to balance the additional expense of the longer reports. I know of nothing more irritating than to be obliged to run through a number of partial reports back to the last original in order to make a proper estimate of a risk.

In the commencement I stated my belief that the uniform report blank with slight amplifications would satisfy all companies. My thought was that three heads should be added to the blanks to make them complete. I would suggest "REMARKS," "USE AND OCCUPANCY," and "GRADING," as those heads. Each of them is being used by some of the bureaus, and I think that the adoption of them as a part of the uniform report blank would be welcomed. Under

Remarks might be included such information as the inspector can gather regarding the prosperity of the risk, including statement of whether or not the plant is running full, and the reasons for any partial shut-down. Of course, if the plant is idle, the fact should be stated and reasons given. Press notices from local papers indicating financial troubles are sometimes valuable. In fact, any information on this subject would be appreciated. There will be opposition in many minds to this suggestion. Think it over and see if a definite scope cannot be worked out that all may safely observe. Under this head, too, the inspector might properly be permitted to express his personal opinions. The opinions of qualified inspectors would be welcomed so long as they did not take the place of facts.

Use and Occupancy.—Your association has adopted a uniform Use and Occupancy Report blank, which provides for all needed information on that subject. The companies who write the class (and their number is increasing), would value a summary of that information in each general inspection report.

Uniform Grading of Sprinkler Equipments.—The question of a uniform schedule for grading sprinkler equipments, I believe is still in the hands of your committee. That this is one of the most perplexing subjects with which you have to contend is readily understandable. The question I have in mind is whether any grading schedule that may be worked out will be of material help to the companies as a whole. I am quite certain that a schedule providing charges for deficiencies in the sprinkler systems based wholly on the rules for sprinkler installation and arrangement of buildings, and giving the results in percentages, would be misleading to a great many men who pass upon business for the companies. I have often heard some such remark as this made, "That is a fine risk, the bureau gives it a grading of 95 per cent." Perhaps the risk was a wholesale dry-goods store, and the statement quoted was sound. On the other hand, it might have been a risk so filled with combustible stock, or so constructed, as to make sprinkler control extremely doubtful, but provided the sprinkler equipment were properly installed and had approved water supplies, it too might grade 95 per cent. Personally I incline to a system that will admit of grading a risk in plain language, as, Excellent, Good, Fair, Indifferent, Poor. This plan is now in use in some bureaus, and seems to have general approval. There is no doubt but that any system should have as a basis some fixed and uniform method of arriving at a grading, but all that need appear in the reports is, for example, "Grading as a sprinklered risk, excellent," this grading to be arrived at with due consideration given to all favorable and unfavorable condition.

Inspectors.—No discussion of the subject of this paper would be complete without giving some time to the question of inspectors. That the companies cannot expect to receive through inspection reports the information they need, unless the men on the firing line who gather the data are thoroughly qualified for the work they have to do, goes without saying. What constitutes proper qualifications is a question not so easily disposed of, for my investigations indicate that there is a marked difference of opinion, among managers of inspection bureaus at least, on that point. Using the uniform inspection blank as a standard, it would seem that there should be no quarrel with the statement that a properly qualified inspector is one who possesses the ability to gather and present, in the prescribed manner, all the information provided for under each head of that blank. I shall not attempt to touch upon questions of temperament and industry here, for I believe there is little difference of opinion respecting the necessities under those heads. The point I feel most strongly about has been stated, and I cannot but believe that there is as much necessity for a uniform standard of qualifications for inspectors as there is for the other standards being worked out by your association. It has been my good fortune to be associated with many inspectors during the time I have been in this business, and I want to say here that as a class they measure high. I wonder at times if we realize fully just how important to the companies and the insured is the work being done by this little army of bright men. I wonder if we realize, to the full, the necessity for very high qualifications in these men upon whose statements, to a large extent, the companies are risking immense sums. In the old days we hewed our inspectors from the raw material, and they made good inspectors. But the hewing took time, and directly or indirectly cost money. In some cases the result was not highly finished. The technical schools now furnish good material for our work, fully equipped in the commencement, and needing only the finish that experience alone can furnish. Now I would not go so far as to say that none but college-bred men should be employed as inspectors, but it is apparent that such men have an immense advantage over those who have to pick up the technical knowledge after they take up field work, even though the latter finally become wholly qualified. As between the college-bred engineer, and the inspector who has knowledge of only a part of the subjects which must be covered in his reports, there can be no comparison. The inspection reports which I read daily give evidence of the point I am endeavoring to elucidate. Some reports are well balanced, furnishing full information under each head in a manner that leaves no doubt in the reader's mind as to the inspector's complete qualification for his work. Others give very full and intelligent description of the fire-defense equipment, but are lamentably weak in other particulars. My belief is that the specialist in a single branch of insurance engineering is not the most satisfactory inspector, which leads me to repeat that there is need for a standard of qualifications for inspectors.

FIRE UNDERWRITERS' UNIFORMITY ASSOCIATION

Standard Uniform Blank for Inspection Report, Adopted 1906

1. Standard form of inspection report.
2. Confidential.
3. Original Sprinklered Risk Report [when such is the case]. No.
4. Name of Association or Bureau. 5. Address.

6. Inspected [Date] Name Inspector.

7. Insurance. [Inserted here are the columns and spaces for information as to policies, lines, dates, etc.]

8. Name of Broker.

9. Survey of [if tenant plant or] Class of Risk [as Shoe Factory] [Omnibus occupancy, give name of owner of plant.] [Exceptions: If principal tenant leases whole plant and sublets portions, or if he occupies most of plant, give his name instead of owner.]

10. Location.

11. Map or Plan. Volume, Name, Date or Date of Correction, Sheet, Block No.

12. Buildings owned by, [Give ownership of individual buildings when plant comprises a group.]

13. Machinery owned by.

14. Occupied by. [Include number of hands employed, how many in full force, hours. In omnibus occupancy group 13 to 18 for each tenant.]

15. Goods made or sold.

16. Raw Stock. [In order used, and any important information, such as proportions of wool, cotton or shoddy, whence supply of latter.]

17. Process. [Describe in order of occurrence, main processes first; then processes of side Products.]

18. Machinery. [Described in order of processes. Mention machinery unused or in reserve.]

19. Location of values.

20. Summary.

21. A complete epitome of report in sequence as herein given. Class of Risk. Construction, including cut-offs [per centum of values subject to one fire]. Exposure. Common hazards. Special hazards. Administration. Protection [accessibility]. Automatic Sprinkler Equipment, grading of sprinkler equipment. Fires. [Prosperity.] Miscellaneous items.

22. Prominent Desirable Features.

23. Prominent Undesirable Features.

24. Remarks.

Construction.

1. Age and repair. 2. Height [including any blind attics].

3. Area. 4. Walls. Materials. Thickness (mention buttresses or pilasters, if any). Finish. Parapet. Coping. Partitions.

5. Roofs (and supports). Material. Cornice. Skylights.

6. Floors and supports. 7. Ceilings.

8. Floor openings. Stairs. Elevators (and hatchways). Light Wells (and air shafts). Chutes. Dumb Waiters, etc.

9. Fire Divisions. Kind, number, etc.

10. Occupancy to be shown by floors for each building (lowest first).

Note: (a) Where there is a general group or where there are groups of buildings, those of similar construction may be described together, using the same general order as separate buildings. (b) Those that are radically different in construction should be described separately.

Exposures.

Distance. Height. Material. Class and Protection against same for North, East, South and West.

Common Hazards.

1. Power. Steam. Electric. Water. Gas or Gasolene Engine.
2. Heating. Steam. Hot Air. Electric. Stoves or Furnaces. Gas.
3. Lighting. Electricity. Gas. Oil Lamps and Torches. Gasolene or vapor Lamps. Candles.
4. Lubricating Oils, etc.

Special Hazards.

Follow order of processes, including drying. Hazards of individual tenants.

Administration.

Management, order, cleanliness; disposition of refuse, oily waste, ashes; smoking, matches, spittoons; shafting; elevator drip pans; master mechanic's knowledge; Assured's care and inspection of fire appliances.

Values And	Insurance
Buildings	Buildings
Machinery	Machinery
Average Stocks	Average Stocks
	Use and Occupancy.
	Rents

Protection.

1. Private inside protection except Automatic Sprinklers. Standpipe Equipment and Water Supplies; Casks, pails and hand chemicals. Other features.
2. Alarm service (including watchman's service, and light he uses. Thermostats, auxiliary fire alarm boxes).
3. Private Outside Protection. Private Hydrant System and Water Supplies. Private Brigade. Open Sprinkler.
4. Public Protection. Water Supply. Public Hydrants. Public Fire Department.
5. Outside Protection as a Whole.

Automatic Sprinkler Equipment.

1. Name of sprinkler. Type or form. Upright or pendant Heads.
2. Portions Sprinklered. By whom put in and When. Wet or what Dry System and Where. Water Column. Dry all year. What Air Pressure. Type. Location of Dry Valve. Enclosed.
3. Portions not Sprinklered. Portions cut off during winter.
4. Public pressure. 5. Gravity Tank. 6. Pressure Tank.
7. Pump. 8. Valves. 9. Alarm Valves and Apparatus.
10. Sprinkler Supervisory Equipment. 11. Size of Risers.
12. Hydrants, Hose or Service Connections on System (including condition of heads; obstruction of valves).
13. Equipment in general (including general information not provided for in above paragraphs).

Record of Fires.

Improvements recommended.

Improvements promised.

INSPECTION OF BUILDINGS BY FIRE DEPARTMENTS

At the 1915 annual convention, in Cincinnati, Ohio, of the International Association of Fire Engineers, which is the official name of the organization of fire chiefs, there was an able report by a committee, of which Chief Kenlon was chairman, outlining the scope and duties of a fire prevention bureau in our American fire departments. In this report the statement is made:

> A careful review of the different fire prevention movements, organizations and bureaus effected to carry on the actual work of fire prevention indicates that only a very few of these have been so organized and empowered that the number of fires ordinarily originating from arson, fraud or carelessness was materially reduced.
>
> . . . .
>
> In the United States and Canada we have, in our effort to save property from loss by fire, directed our efforts mostly towards improving our fire fighting facilities. The losses can be kept down to a certain margin by increasing the efficiency and strength of our departments, but any additional strength beyond that is largely as security against conflagrations. Some of our fire departments have already reached or are approaching that stage of development. Therefore, if we hope to reduce our losses to the figure at which it is reasonable to expect they should be kept, we must turn our attention to the question of fire prevention. In the same way that the State and municipality have directed their efforts to health regulations, which have resulted in a lower death rate and an extension of the average life of man, so will the State and municipality have to turn attention to fire prevention regulations.
>
> So far as the municipality is concerned, the time is rapidly approaching when every city and town will be compelled to incorporate in its fire department, not only the work of fire extinguishment but the work of fire prevention also, particularly if it expects to keep its losses low.

It is seen from the above that it is becoming generally recognized that one of the duties of a fire department is to have remedied hazardous conditions and to order the introduction of protective devices, and to do this they must make inspection, judge of conditions and issue regulatory specifications. In this last they have wisely adopted many of the very excellent regulations and suggested ordinances of the National Board of Fire Underwriters, and every year sees more and more cities carrying out the underwriters' recommendations for more stringent laws on common hazards and proper construction.

It is to the first two duties—inspection and judging conditions—that attention has to be called. Not every one can make an inspection; any underwriters' inspection bureau can vouch for this, as it is only after months of careful coaching and through the use of inspection blanks compiled after careful study that a real good inspection can be obtained from even the best of material. Firemen have not in the past had the training, and the time they can put on it is so limited by other duties that it will take even longer for them to become proficient. It is because of this that much of the fire prevention work started will have no material effect for some years, as it will take this long to have the firemen well qualified in their duties as inspectors.

This lack of previous experience in inspection work, together with the fact that the men and officers have been so occupied in fire fighting that they have not had time to master the intricacies of fire prevention, also lessens their ability to judge of the seriousness of hazards and the best method of eliminating them, or the proper fire protection features to be provided.

In both of these matters—inspection and judgment of conditions—the underwriters have had long years of training and have become most expert. Evidently, considering this, and that all prevention work is of most vital importance to the fire underwriters, it is their duty to assist the fire departments in every way possible.

There have been numerous cases where an underwriters' inspector has found such "horrid" conditions that he has felt it his duty to call the fire chief's attention to it, but this is not sufficiently general. After the Salem fire, the fire department and the insurance interest condemned each other for the hazardous storage of film scrap, which resulted in burning up millions of dollars in property. The insurance interests blamed the fire department for allowing this storage, in this poorly protected manner, and the fire department condemned the insurance inspectors for not notifying them of it when the inspectors had found such poor conditions.

It is to offset this that there is a real duty for the underwriters. With every inspection of importance, if possible, have a fireman detailed along, to see first-hand the conditions found. In many cases this will not be feasible, either for lack of firemen or for disinclination on the part of the fire department officials. As an alternative, almost as good, file with the fire department a duplicate of the inspection blank, not only as to the conditions found, which in many cases will be more completely covered than any inspection by a fireman, but also as to the changes necessary.

These inspection blanks thus filed will be a constant reminder to the Chief of conditions existing and will also enable him to check up the thoroughness of any individual inspections made by members of the fire force.

With the advice of the underwriters' inspector on file as to the changes and improvements judged necessary, the fire chief will be enabled to furnish information at any time to an owner wishing to make changes in a plant, and even where conditions are somewhat different, the precedent offered by some other report may be of sufficient value to result in material changes.

In all large cities there are well organized underwriters' inspection bureaus, and these should by all means co-operate to the fullest extent with the fire department to remedy conditions. It might even be possible, by ordinance or legislative enactment, to make the underwriters' inspector a deputy inspector of the fire department, as has been done in some cases with electrical inspectors, and on the Pacific Coast with the city Fire Marshal, who is an insurance bureau employee.

METRIC WEIGHTS AND MEASURES

Metric Weights

Milligram (1/1000 gram) equals 0.0154 grain
Centigram (1/100 gram) equals 0.1543 grain
Decigram (1/10 gram) equals 1.5432 grains
Gram equals 15.432 grains
Decagram (10 grams) equals 0.3527 ounce
Hectogram (100 grams) equals 3.5274 ounces
Kilogram (1000 grams) equals 2.2046 pounds
Myriagram (10,000 grams) equals 22.046 pounds
Quintal (100,000 grams) equals 220,46 pounds
Millier or tonnea—ton (1,000,000 grams) equals 2,204.6 pounds

Metric Dry Measures

Milliliter (1/1000 liter) equals 0.061 cubic inch
Centiliter (1/100 liter) equals 0.6102 cubic inch.
Deciliter (1/10 liter) equals 6.1022 cubic inches
Liter equals 0.908 quart
Decaliter (10 liters) equals 9.08 quarts
Hectoliter (100 liters) equals 2.838 bushels
Kiloliter (1000 liters) equals 1,308 cubic yards

Metric Liquid Measures

Milliliter (1/1000 liter) equals 0.0338 fluid ounce
Centiliter (1/100 liter) equals 0.338 fluid ounce
Deciliter (1/10 liter) equals 0.845 gill
Liter equals 1.0567 quarts
Decaliter (10 liters) equals 2.6418 gallons
Hectoliter (100 liters) equals 26.417 gallons
Kiloliter (1000 liters) equals 264.18 gallons

Metric Measures of Length

Millimeter (1/1000 meter) equals 0.0394 inch
Centimeter (1/100 meter) equals 0.3937 inch
Decimeter (1/10 meter) equals 3.937 inches
Meter equals 39.37 inches
Decameter (10 meters) equals 393.7 inches
Hectometer (100 meters) equals 328 feet 1 inch
Kilometer (1000 meters) equals 0.62137 mile (3,280 feet 10 inches)
Myriameter (10,000 meters) equals 6.2137 miles

Metric Surface Measures

Centare (1 square meter) equals 1,550 square inches
Are (100 square meters) equals 119.6 square yards
Hectare (10,000 square meters) equals 2.471 acres

WEIGHTS AND MEASURES

Troy Weight

24 grains = 1 pwt.
20 pwts. = 1 ounce
12 ounces = 1 pound

Used for weighing gold, silver and jewels

Apothecaries' Weight

20 grains = 1 scruple
3 scruples = 1 dram
8 drams = 1 ounce
12 ounces = 1 pound

The ounce and pound in this are the same as in Troy weight

Avoirdupois Weight

27 11/32 grains = 1 dram
16 drams = 1 ounce
16 ounces = 1 pound
24 pounds = 1 quarter
4 quarters = 1 cwt.
2,000 lbs. = 1 short ton
2,240 lbs. = 1 long ton

Dry Measure

2 pints = 1 quart
8 quarts = 1 peck
4 pecks = 1 bushel
37 bushels = 1 chaldron

Liquid Measure

4 gills = 1 pint
2 pints = 1 quart
4 quarts = 1 gallon
31 1/2 gallons = 1 barrel
2 barrels = 1 hogshead

Long Measure

12 inches = 1 foot
3 feet = 1 yard
5 1/2 yards = 1 rod
40 rods = 1 furlong
8 furlongs = 1 sta. mile
3 miles = 1 league

Mariner's Measure

6 feet = 1 fathom
120 fathoms = 1 cable length
7 1/2 cable lengths = 1 mile
5,280 feet = 1 stat. mile
6,085 feet = 1 naut. mile

Miscellaneous

3 inches = 1 palm
4 inches = 1 hand
6 inches = 1 span
18 inches = 1 cubit
21.8 inches = 1 Bible cubit
2 1/2 feet = 1 military pace

Square Measure

144 square inches = 1 square foot
9 square feet = 1 square yard
30 1/4 square yards = 1 square rod
40 square rods = 1 rood
4 roods = 1 acre
640 acres = 1 square mile

Surveyors' Measure

7.92 inches = 1 link
25 links = 1 rod
4 rods = 1 chain
10 sq. chains or 160 sq. rods = 1 acre
640 acres = 1 square mile
36 sq. miles (6 miles sq.) = 1 township

Cubic Measure

1,728 cubic inches = 1 cubic foot
27 cubic feet = 1 cubic yard
2,150.42 cu. in. = 1 standard bushel
231 cu. in. = 1 standard gallon
1 cubic foot = about 4/5 of a bushel
128 cubic feet = 1 cord (wood)
40 cubic feet = 1 ton (shipping)

HORSE POWER

A horse power is the energy required to raise 33,000 pounds one foot in a minute.

The horse power of a boiler is its capacity to evaporate 30 pounds of water per hour at 70 gauge pressure (temperature 318.4 deg.) from 100 deg. feed water for every horse power.

The indicated horse power of an engine is the power developed by the steam on the piston without any deduction for friction.

The effective horse power of an engine is the actual and available horse power delivered to the belt or gearing, and is always less than the indicated.

The horse power of an engine is

$$\frac{a \times p \times v}{33,000}$$

a—Area of piston in square inches.
p—Means effective pressure of the steam on the piston per square inch.
v—Velocity of piston per minute.

Rule to Ascertain Horse Power of Compound Engine

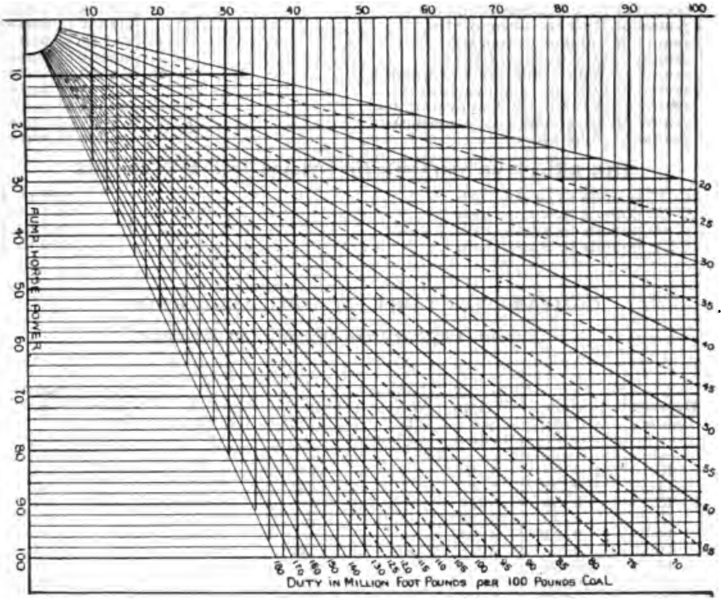
Multiply stroke of piston in feet by the number of revolutions per minute; multiply this product by the boiler pressure by gauge and take the square root of this result, which multiply by the square of the diameter of the low pressure cylinder. This product, divided by 8,500, will be the estimated horse power of the engine.

An indicated horse power requires, in the best condensing engines, about 1½ gallons of water evaporated per hour.

An indicated horse power, in large non-condensing engines, requires about 2½ gallons of water evaporated per hour.

An indicated horse power, in small non-condensing engines, requires from 3 to 10 gallons of water evaporated per hour.

BOILER HORSE POWER (BASED ON 30 POUNDS OF WATER PER HOUR)



STEAM BOILER PROPORTIONS

Proportion of grate and heating surface required for a given horse power. The term horse power here means capacity to evaporate 34.5 lbs. of water from and at 212 degrees F.

Average proportions for maximum economy for land boilers fired with good anthracite coal:

Heating surface per horse power	10.0 sq. ft.
Grate surface per horse power	1/3 sq. ft.
Ratio of heating to grate surface	30.0 sq. ft.
Water evaporated from and at 212 degs. per sq. ft. H. S. per hour	3 lbs.
Combustible burned per H. P. per hour	3 lbs.
Coal with 1/6 refuse pounds per H. P. per hour	3.6 lbs.
Combustible burned per sq. ft. grate per hour	9 lbs.
Coal with 1/6 refuse lbs. per sq. ft. grate per hour	10.8 lbs.
Water evaporated from and at 212 degs. per lb. combustible	11.5 lbs.
Water evaporated from and at 212 degs. per lbs. coal (⅙ refuse)	9.6 lbs.

HORSE POWER OF CYLINDRICAL FLUE BOILER

G = Fire grate surface in square feet
H = Nominal horse power
S = Heating surface in square yards

$$\sqrt{SG} = H \qquad \frac{H^2}{G} = S \qquad \frac{H^2}{S} = G$$

For cylindrical two-flued boilers an approximate rule is:

$$\frac{\text{Length x diam.}}{6} = \text{nominal horse power.}$$

To find the weight of the rim of the fly-wheel for an engine:

$$\frac{\text{Nominal H. P. x 2000}}{\text{The square of the velocity of the circumference in feet per second}} = \text{Weight in cwts.}$$

AVERAGE EVAPORATIVE POWER OF FUELS

1 pound of pure Carbon evaporates	12.4	pounds of water
1 pound of Hydrogen evaporates	53.	pounds of water
1 pound of Sulphur evaporates	3.44	pounds of water
1 pound of Oak wood evaporates	6.47	pounds of water
1 pound of White Pine wood evaporates	7.65	pounds of water
1 pound of Oak charcoal evaporates	11.7	pounds of water
1 pound of Bituminous coal evaporates	12.62	pounds of water
1 pound of Anthracite coal evaporates	10.9	pounds of water
1 pound of Coke evaporates	11.85	pounds of water

THE RELATIVE VOLUME OF STEAM AND WATER ARE

At 15 pounds to square inch	1669 to 1
At 30 pounds to square inch	881 to 1
At 60 pounds to square inch	467 to 1
At 120 pounds to square inch	249 to 1

COMPARATIVE TABLE—WEIGHT AND GRAVITY

Liquids Lighter than Water at 60 degrees F.

Degrees Baume	Specific Gravity	Actual Weight per Gallon	Billing Weight per Gallon	Degrees Baume	Specific Gravity	Actual Weight per Gallon	Billing Weight per Gallon
10	1.0000	8.32	..	43	.8092	6.74	6⅝
11	.9929	8.27	..	44	.8045	6.70	6⅝
12	.9859	8.21	..	45	.8000	6.66	6⅝
13	.9790	8.16	..	46	.7951	6.63	6⅝
14	.9722	8.10	..	47	.7909	6.59	6½
15	.9655	8.04	..	48	78.65	6.55	6½
16	.9589	7.99	..	49	.7821	6.52	6½
17	.9523	7.93	..	50	.7777	6.48	6⅜
18	.9459	7.88	..	51	.7734	6.44	6⅜
19	.9395	7.83	..	52	.7692	6.41	6⅜
20	.9333	7.78	..	53	.7650	6.37	6⅜
21	.9271	7.72	..	54	.7608	6.34	6¼
22	.9210	7.67	..	55	.7567	6.30	6¼
23	.9150	7.62	7½	56	.7526	6.27	6¼
24	.9090	7.57	7½	57	.7486	6.24	6¼
25	.9032	7.53	7½	58	.7446	6.20	6⅛
26	.8974	7.48	7⅜	59	.7407	6.17	6⅛
27	.8917	7.43	7⅜	60	.7368	6.14	6⅛
28	.8860	7.38	7⅜	61	73.29	6.11	6⅛
29	.8805	7.34	7¼	62	.7290	6.07	6
30	.8750	7.29	7¼	63	.7253	6.04	6
31	.8695	7.24	7¼	64	.7216	6.01	6
32	.8641	7.20	7¼	65	.7179	5.98	6
33	.8588	7.15	7⅛	66	.7142	5.95	5⅞
34	.8536	7.11	7⅛	67	.7106	5.92	5⅞
35	.8484	7.07	7	68	.7070	5.89	5⅞
36	.8433	7.03	7	69	.7035	5.86	5⅞
37	.8383	6.98	7	70	.7000	5.83	5¾
38	.8333	6.94	6⅞	75	.6829	5.69	5¾
39	.8284	6.90	6⅞	80	.6666	5.55	5½
40	.8235	6.86	6⅞	85	.6511	5.42	5⅜
41	.8187	6.82	6⅞	90	.6363	5.30	..
42	.8139	6.78	6⅞	95	.6222	5.18	..

NOTE.—This table of Baume's hydrometers has been used for many years as the basis for all instruments employed in the petroleum trade. It is calculated for a temperature of 60° Fahr. and is based on the formulae: $\frac{140}{B° + 130}$ = Specific gravity and $\frac{140}{\text{Specific gravity}} - 130$ = Bo. This table has the official sanction of the National Bureau of Standards, Washington, D. C.

COMPARATIVE TABLE—WEIGHT AND GRAVITY

Liquids Heavier than Water at 60 Degrees F.

Baume	Specific Gravity	Pounds in Gallon	Baume	Specific Gravity	Pounds in Gallon
1	1.0069	8.38	36	1.3302	11.09
2	1.0139	8.46	37	1.3425	11.18
3	1.0211	8.51	38	1.3551	11.29
4	1.0283	8.56	39	1.3679	11.39
5	1.0357	8.63	40	1.3809	11.51
6	1.0431	8.69	41	1.3942	11.61
7	1.0507	8.75	42	1.4077	11.72
8	1.0583	8.81	43	1.4215	11.34
9	1.0661	8.88	44	1.4356	11.96
10	1.0740	8.94	45	1.4500	12.08
11	1.0820	9.01	46	1.4646	12.21
12	1.0902	9.09	47	1.4795	12.33
13	1.0984	9.15	48	1.4949	12.46
14	1.1068	9.21	49	1.5104	12.58
15	1.1153	9.29	50	1.5263	12.72
16	1.1240	9.36	51	1.5425	12.85
17	1.1328	9.43	52	1.5591	12.99
18	1.1417	9.51	53	1.5760	13.13
19	1.1507	9.59	54	1.5934	13.27
20	1.1600	9.67	55	1.6111	13.42
21	1.1693	9.74	56	1.6292	13.57
22	1.1788	9.81	57	1.6477	13.72
23	1.1885	9.90	58	1.6666	13.87
24	1.1983	9.99	59	1.6860	14.04
25	1.2083	10.07	60	1.7056	14.20
26	1.2184	10.16	61	1.7261	14.38
27	1.2288	10.24	62	1.7469	14.55
28	1.2393	10.32	63	1.7682	14.72
29	1.2500	10.41	64	1.7901	14.91
30	1.2608	10.51	65	1.8125	15.10
31	1.2719	10.59	66	1.8354	15.29
32	1.2831	10.69	67	1.8589	15.48
33	1.2946	10.78	68	1.8831	15.68
34	1.3063	10.84	69	1.9079	15.89
35	1.3181	10.98	70	1.9333	16.10

NOTE.—This table of Baume's hydrometer was adopted in 1903 as the basis for all instruments employed in the manufacture of acids and alkalies by the Manufacturing Chemists' Association of the United States. It has the official sanction of the National Bureau of Standards, Washington, D. C.

It is calculated for a temperature of 60 degrees Fahr. and is based upon the formulae:

$$\frac{145}{B^\circ + 145} = \text{Specific gravity and } 145 - \frac{145}{\text{Specific gravity}} = B^\circ.$$

COMPARATIVE TABLE—WIRE AND SHEET METAL GAUGES

Number of Gauge	Birmingham (or Stubs' Iron) Wire Gauge	American or Brown and Sharpe Gauge	Roebling's and Washburn Moen's Gauge	Stubs' Steel Wire Gauge	British Imperial Standard Wire Gauge (Legal Standard in Great Britain since March 1, 1884)		U. S. Standard Gauge for Sheet and Plate Iron and Steel, 1893	Number of Gauge
	inch	inch	inch	inch	inch	millim.	inch	
0000000			.49		.500	12.7	.5	7/0
000000			.46		.464	11.78	.469	6/0
00000			.43		.432	10.97	.438	5/0
0000	.454	.46	.393		.4	10.16	.406	4/0
000	.425	.40964	.362		.372	9.45	.375	3/0
00	.38	.3648	.331		.348	8.84	.344	2/0
0	.34	.32486	.307		.324	8.23	.313	0
1	.3	.2893	.283	.227	.3	7.62	.281	1
2	.284	.25763	.263	.219	.276	7.01	.266	2
3	.259	.22942	.244	.212	.252	6.4	.25	3
4	.238	.20431	.225	.207	.232	5.89	.234	4
5	.22	.18194	.207	.204	.212	5.38	.219	5
6	.203	.16202	.192	.201	.192	4.88	.203	6
7	.18	.14428	.177	.199	.176	4.47	.188	7
8	.165	.12849	.162	.197	.16	4.06	.172	8
9	.148	.11424	.148	.194	.144	3.66	.156	9
10	.134	.10189	.135	.191	.128	3.25	.141	10
11	.12	.09074	.12	.188	.116	2.95	.125	11
12	.109	.08081	.105	.185	.104	2.64	.109	12
13	.095	.07196	.092	.182	.092	2.34	.094	13
14	.033	.06403	.08	.180	.08	2.03	.078	14
15	.072	.05707	.072	.178	.072	1.83	.07	15
16	.053	.05082	.063	.175	.064	1.63	.0625	16
17	.058	.04526	.054	.172	.056	1.42	.0563	17
18	.049	.0403	.047	.168	.048	1.22	.05	18
19	.042	.03589	.041	.164	.04	1.02	.0438	19
20	.035	.03196	.035	.161	.036	.91	.0375	20
21	.032	.02846	.032	.157	.032	.81	.0344	21
22	.028	.02535	.028	.155	.028	.71	.0313	22
23	.025	.02257	.025	.153	.024	.61	.0281	23
24	.022	.0201	.023	.151	.022	.56	.025	24
25	.02	.0179	.02	.148	.02	.51	.0219	25
26	.018	.01594	.018	.146	.018	.46	.0183	26
27	.016	.01419	.017	.143	.0164	.42	.0172	27
28	.014	.01264	.016	.139	.0148	.38	.0156	28
29	.013	.01126	.015	.134	.0136	.35	.0141	29
30	.012	.01002	.014	.127	.0124	.31	.0125	30
31	.01	.00893	.013	.120	.0116	.29	.0109	31
32	.009	.00795	.013	.115	.0108	.27	.0101	32
33	.008	.00708	.011	.112	.01	.25	.0094	33
34	.007	.0063	.01	.110	.0092	.23	.0086	34
35	.005	.00561	.00	.108	.0084	.21	.0078	35
36	.004	.005	.009	.106	.0076	.19	.007	36
37		.00445	.0085	.103	.0068	.17	.0066	37
38		.00396	.008	.101	.006	.15	.0063	38
39		.00353	.0075	.099	.0052	.13		39
40		.00314	.007	.097	.0048	.12		40

TABLE FOR CONVERTING PRESSURE IN FEET HEAD OF WATER INTO POUNDS PER SQUARE INCH

Feet	0	1	2	3	4	5	6	7	8	9
10	4.33	4.76	5.20	5.63	6.03	6.50	6.93	7.36	7.80	8.23
20	8.66	9.10	9.53	9.96	10.39	10.83	11.26	11.69	12.13	12.56
30	12.99	13.43	13.86	14.29	14.73	15.16	15.59	16.02	16.46	16.89
40	17.32	17.76	18.19	18.62	19.06	19.49	19.92	20.36	20.79	21.22
50	21.65	22.09	22.52	22.95	23.39	23.82	24.25	24.69	25.12	25.55
60	25.99	26.42	26.85	27.28	27.72	28.15	28.58	29.02	29.45	29.88
70	30.32	30.75	31.18	31.62	32.05	32.48	32.91	33.34	33.78	34.21
80	34.65	35.08	35.51	35.95	36.38	36.81	37.25	37.68	38.11	38.58
90	38.98	39.41	39.84	40.28	40.71	41.14	41.58	42.01	42.44	42.88
100	43.31	43.74	44.18	44.61	45.04	45.47	45.91	46.34	46.77	47.21
110	47.64	48.07	48.51	48.94	49.37	49.81	50.24	50.67	51.10	51.54
120	51.97	52.40	52.84	53.27	53.70	54.14	54.57	55.00	55.44	55.87
130	56.30	56.73	57.17	57.60	58.03	58.48	58.90	59.33	59.77	60.20
140	60.63	61.07	61.50	61.93	62.37	62.80	63.23	63.66	64.10	64.53
150	64.96	65.40	65.83	66.26	66.70	67.13	67.56	68.00	68.43	68.86
160	69.29	69.73	70.16	70.59	71.03	71.43	71.89	72.33	72.76	73.19
170	73.63	74.06	74.49	74.92	75.36	75.79	76.22	76.66	77.09	77.52
180	77.96	78.39	78.82	79.26	79.69	80.12	80.55	80.99	81.42	81.85
190	82.29	82.72	83.15	83.59	84.02	84.45	84.89	85.32	85.75	86.19
200	86.62	87.05	87.48	87.92	88.35	88.78	89.22	89.65	90.08	90.52
210	90.95	91.38	91.82	92.25	92.68	93.11	93.58	93.98	94.41	94.85
220	95.28	95.71	96.15	96.58	97.01	97.45	97.88	98.31	98.74	99.18
230	99.61	100.04	100.48	100.91	101.34	101.78	102.21	102.64	103.08	103.51
240	103.94	104.38	104.81	105.25	105.68	106.11	106.54	106.97	107.41	107.84
250	108.27	108.71	109.14	109.57	110.01	110.44	110.87	111.30	111.74	112.17
260	112.60	113.04	113.47	113.90	114.34	114.77	115.20	115.64	116.07	116.50
270	116.93	117.37	117.80	118.23	118.67	119.10	119.53	119.97	120.40	120.83
280	121.27	121.70	122.13	122.56	123.00	123.43	123.86	124.30	124.73	125.16
290	125.60	126.03	126.46	126.90	127.33	127.76	128.19	128.63	129.06	129.49
300	129.93	130.36	130.79	131.23	131.66	132.09	132.53	132.96	133.39	133.82
310	134.26	134.69	135.13	135.57	136.00	136.44	136.87	137.31	137.74	138.08
320	138.51	138.95	139.38	139.85	140.39	140.75	141.19	141.62	142.05	142.48
330	142.89	143.32	143.75	144.19	144.62	145.05	145.49	146.92	146.35	146.78
340	147.22	147.65	148.08	148.52	148.95	149.38	149.81	150.24	150.67	151.12
350	151.58	152.01	152.44	152.88	153.31	153.75	154.18	154.62	155.05	155.49

TABLE OF HORSE POWERS REQUIRED TO PUMP ONE MILLION GALLONS OF WATER FROM 10 TO 209 POUNDS

Pounds		1	2	3	4	5	6	7	8	9
10	4.05	4.46	4.86	5.27	5.67	6.08	6.48	6.89	7.30	7.70
20	8.1	8.5	8.9	9.3	9.7	10.1	10.5	10.9	11.3	11.7
30	12.1	12.5	13.0	13.4	13.8	14.2	14.6	15.0	15.4	15.8
40	16.2	16.6	17.0	17.4	17.8	18.2	18.6	19.0	19.4	19.8
50	20.3	20.7	21.1	21.5	21.9	22.3	22.7	23.1	23.5	23.9
60	24.3	24.7	25.1	25.5	25.9	26.3	26.7	27.1	27.6	28.0
70	28.4	28.8	29.2	29.6	30.0	30.4	30.8	31.2	31.6	32.0
80	32.4	32.8	33.2	33.6	34.0	34.4	34.8	35.3	35.7	36.1
90	36.5	36.9	37.3	37.7	38.1	38.5	38.9	39.3	39.7	40.1
100	40.5	40.9	41.3	41.7	42.1	42.6	43.0	43.4	43.8	44.2
110	44.6	45.0	45.4	45.8	46.2	46.6	47.0	47.4	47.8	48.2
120	48.6	49.0	49.4	49.8	50.3	50.7	51.1	51.5	51.9	52.3
130	52.7	53.1	53.5	53.9	54.3	54.7	55.1	55.5	55.9	56.3
140	56.7	57.1	57.5	58.0	58.4	58.8	59.2	59.6	60.0	60.4
150	60.8	61.2	61.6	62.0	62.4	62.8	63.2	63.6	64.0	64.4
160	64.8	65.3	65.7	66.1	66.5	66.8	67.3	67.7	68.1	68.5
170	68.9	69.3	69.7	70.1	70.5	70.9	71.3	71.7	72.1	72.6
180	73.0	73.4	73.8	74.2	74.6	75.0	75.4	75.8	76.2	76.6
190	77.0	77.4	77.8	78.2	78.6	79.0	79.4	79.8	80.3	80.7
200	81.1	81.5	81.9	82.3	82.7	83.1	83.5	83.9	84.3	84.7

APPENDIX

ACETYLENE APPARATUS

At the meeting of the National Fire Prevention Association in May, 1916, a revision of the regulations covering the above was submitted; to a large extent it was a rewording of the rules given herein on pages 187 to 190 inclusive. The principal changes were a recommendation that the carbide be kept in the generator house and that rating of generators be on capacity of carbide and rate of generation in cubic feet of gas, rather than on the basis of number of lights, as heretofore, and a 9-hour lighting period is called for.

The following introductory is inserted:

General Precautions

Failure to observe the following precautions and specifications will endanger life as well as property.

1. CHARACTERISTICS OF ACETYLENE

(a) Acetylene becomes an explosive compound under certain conditions and must be handled with care.

(b) Mixtures of acetylene and air very explosive and must be carefully guarded against.

(c) Under no conditions must acetylene be subjected to more than 15 pounds pressure unless it is dissolved in acetone or other approved solvent and contained in a cylinder of the type described in Class E.

Self-compression generators which develop pressures above 15 pounds to the square inch are absolutely prohibited.

(d) The use of liquid acetylene, or gas generated therefrom is absolutely prohibited.

(e) Tests of generators or piping for leaks must not be made with a flame, and a flame must never be applied to an outlet from which the burner has been removed. Tests for leaks should be made with soap and water.

(f) Soldering irons should not be used on acetylene generators until it is certain that all gas has been removed. Soldering irons should never be used on acetylene cylinders under any conditions.

In determining the size of generators, each pound of carbide in the charge is assumed as capable of producing 4½ cubic feet of gas, and an allowance of not more than ½ cubic foot per hour per pound of carbide in the charge may be made. The suggested regulations omit the requirements on pipe sizes for the house piping, but this is being worked up in conjunction with the U. S. Bureau of Standards as Part 4 of a National Safety Code and will be included later.

In addition to the regulations for Classes A, B and C, regulations were also compiled for Classes D and E; these are as follows:

Class D—Stationary Automatic Generators Permitted for Outside Installation

1. SIZE AND STYLE OF GENERATOR

(a) The capacity of any generator of the automatic type shall be sufficient to furnish acetylene continuously for the maximum lighting period to all lights installed. A lighting period of at least nine hours shall be provided for in every case and for conditions of service requiring lighting periods of more than nine hours shall be of sufficient capacity to avoid recharging by artificial light. In determining the size of generator required each pound of carbide in the charge may be estimated as capable of producing four and one-half cubic feet of gas.

(b) In selecting a generator, an allowance of not more than one-half cubic foot of acetylene per hour shall be made for each pound of carbide in the rated charge.

(c) A small generator shall never be installed to supply a large number of lights, even though it seems probable that only a few lights will be used at a time.

(d) Burners are usually marked to indicate the cubic feet of acetylene which they consume per hour.

2. MAKERS INSTRUCTIONS TO BE FOLLOWED

(a) When installing generators, the instruction card furnished by the maker should be carefully read and its directions followed in every detail.

(b) Approved warning and instruction cards provided by the maker should be posted in a well lighted position near the generator so that the operator may consult them conveniently from time to time.

3. LOCATION

Generators of this class when installed in accordance with Rule 2, are to be installed 30 feet from buildings where possible but never less than 10 feet removed and so as not to expose openings into buildings.

4. ACCESSIBILITY TO UNAUTHORIZED PERSONS

Generators shall be kept under lock and key.

5. PROTECTION AGAINST FREEZING

Generators must be protected against freezing. No salt or other corrosive chemical is permissible as a protection against freezing.

6. WATER SUPPLY CONNECTION

Water must not be supplied through a continuous connection leading into the generator. In cases where generators are supplied with water from city water mains or house pipes, no direct pipe connection with the generator is permitted. The supply pipe must terminate some distance above the regularly provided opening for filling so that the water can be observed as it enters the generator.

7. DRAIN CONNECTION

Machines of the carbide-feed type must not be fitted with continuous drain connections leading to sewers, but must discharge into suitable open receptacles which may have such connections.

8. CARE OF GENERATORS

(a) In the care of generators, always clean and recharge the generating chambers at regular intervals regardless of the number of burners actually used. This work should be done at a regular time, during daylight hours only.

(b) Where generators are not used throughout the entire year, always first remove all carbide and then drain and clean thoroughly at the end of the season in which they are in service.

(c) In order to remove all gas from the machine, it is generally necessary to take out the bell portion and invert it so that the gas can readily escape. This should never be done in the presence of artificial light or fire of any kind.

(d) Whenever repairs are to be made or the generator is to be charged or carbide is to be removed, the water chamber should be full during this operation to avoid the danger of explosive mixture of air and gas within the water space and also to prevent the dropping of fresh carbide into sufficient water.

9. RECHARGING GENERATORS

(a) The carbide added each time the generator is recharged should be sufficient to completely fill the space provided for carbide without packing or ramming the charge.

(b) When recharging carbide-feed generators, observe the following order of operations strictly: first, clean out generating chamber; second, immediately fill with clean water; third, fill hopper with carbide. Never attempt to introduce carbide until after generating chamber is completely filled with water. Be careful not to place in the generators less than one gallon of water for each pound of the carbide capacity and not to bring the water above the point marked on the machine as the proper level.

(c) Whenever any fresh carbide is added to the supply in a carbide-feed generator, this must be done only after the water supply has been completely replenished in accordance with paragraph b above. This precaution is necessary to avoid otherheating during generation and accumulation of a heavy deposit of residuum in the generating chamber.

(d) In the type of generators where the hopper is lifted out for recharging, care should be taken that the hopper is set in a dry place, not on damp ground or snow which would cause slacking of the carbide around the feeding mechanism.

10. MANIPULATION BY DAYLIGHT REQUIRED

All charging and cleaning of apparatus and execution of repairs shall be done during daylight hours and by natural light only.

Never use a lighted match, lamp, candle, lantern or any other flame near the generator.

11. PIPING

(a) Rules for house piping are to be the same as those for Standard Automatic Generators for Inside Installation.

(b) Outside piping connecting generator with buildings shall be sharply graded to the lowest point outside of buildings and where condensation is not provided for by the piping draining into the generator, a drip shall be provided at such lowest point to take care of condensation. This drip must be so constructed as to permit draining or pumping out the condensation at necessary intervals.

(c) All underground piping to be galvanized and exposed threads covered with a non-corrosive covering.

(d) Underground piping shall be of an even slope from any direction to the low point. Substantial block supports should be put under the piping at intervals especially at the joints.

(e) Gas cock should be provided inside of all buildings where it can be conveniently reached near the point of entrance so as to permit shutting off gas supply from any building.

Class E—Dissolved Acetylene Under Pressure for Use in Lighting Systems

1. CYLINDERS

Cylinders accepted for transportation in Interstate Commerce and bearing labels to the effect that they comply with Interstate Commerce Commission regulations or bearing test marks as prescribed in paragraph 14 of Interstate Commerce Commission shipping container specifications No. 8, effective October 1st, 1914, shall be considered suitable for employment in any acetylene lighting installation.

2. INSTALLATION

a. Cylinders shall be installed on outside of any building or in well ventilated compartments of vessels.

b. Where installed for house lighting must be protected against mechanical injury or tampering by suitable ventilated box of durable construction arranged to be kept locked.

c. Cylinders should be connected to the permanent house or vessel piping with extra heavy steel tubing or pipe.

d. Between cylinders and low pressure piping there shall be installed a pressure gauge to serve as an indicator of pressure in the cylinder or cylinders provided such gauge is not a permanent part of cylinder, and an automatic pressure regulator designed to reduce the high pressure of the cylinders to the low pressure employed in the lighting systems.

On the low pressure side of the automatic pressure regulator shall be installed an approved type of mechanical or mercury pressure relief arranged to release pressure from cylinders in the event of derangement of pressure reducing mechanism which would otherwise allow the accumulation of high pressure from cylinders to enter the low pressure system.

Such pressure release is of mercury to be of self-restoring type releasing direct to outside and to be simple in design and construction.

3. PIPING

Permanent piping in houses or on vessels to be of standard iron pipe or of seamless brass tubing, such tubing to be of not less than one-fourth inch outside dimension, having sufficient internal diameter to insure adequate supply of gas within the working range of the low pressure of 5 lbs. per square inch maximum in the system.

Seamless brass tubing to withstand a test pressure of 500 lbs. per square inch and to be installed as per item 53e and notes to same (from rules—proposed—for installation and use of Class C, semi-portable automatic apparatus).

Seamless brass tubing to be made up with connections of the compression coupling type (these being in our opinion far superior to soldered joints or flared union couplings).

1916 REPORT OF NATIONAL FIRE PROTECTION ASSOCIATION COMMITTEE ON AUTOMATIC SPRINKLERS

Dry Pipe Sprinkler Systems in Refrigeration Rooms

Ice formations of such a character as to seriously impair the automatic sprinkler protection have been reported in a number of cold storage warehouses, following detailed examinations of the piping by several inspection departments.

Your committee was requested to consider this subject, recommend a uniform method for conducting further tests, and solicit co-operation of the various inspection departments, with a view to ascertaining if these formations may be expected generally in properties of the class, and if so, if adequate preventive measures have been or can be devised. A uniform blank has, therefore, been distributed by the committee among such of the active members as it should interest and the promise of co-operation has been very satisfactory. As, however, the blank was not issued until after the first of the year, there has not been sufficient time to furnish the required information for any extended committee report at this time.

Technically, there is danger of such ice formation from the presence alone of the priming water of the dry pipe valve, ignoring entirely any moisture that may enter the system through the air compressor or by other means. Until there is opportunity, however, to secure details from the further examinations, and to enquire particularly into remedial measures which have already been adopted and said to be effective, or that have been proposed, your committee would prefer not to recommend any action through the sprinkler regulations. Permission is, therefore, requested to continue the matter further, and the co-operation of anyone interested in this particular subject is earnestly solicited.

Among the various measures that have already been adopted or recommended are: Calcium chloride reservoir in the discharge line from the air compressor, ammonia cooled dessicator or freezer, oil seal on priming water of dry pipe valve, calcium chloride reservoir in the main riser above the dry pipe valve, separator in the discharge line from the air compressor, air suction from freezer room, by-passes in the sprinkler lines in which the ice crystals may build up leaving the sprinkler pipes free, greater pitch to the sprinkler piping and use of a greater number of flanged connections, maintaining at least one foot air space where possible between the sprinkler piping and the refrigeration coils or insulation of piping where in contact with or in close proximity to such coils, rearranging present methods of air connections, connection of anti-columning pipe where used to be within the warm dry pipe valve enclosure, where feasible sprinkler piping for freezer sections to be kept entirely separate from the sprinkler piping in the rest of the property.

In this connection, your committee would point out that any pre-drying arrangement is ineffective if the air connection enters the system in such a manner that the air will pass through the priming water, or any drainage that may lie on top of the priming water, as is extremely likely to be the case in the method adopted for air connection with some types of dry pipe valves. Particular attention is called to rule 54 of the sprinkler regulations in this respect, which states that the air connection should enter the system in the main riser above the dry pipe valve.

Method of Conducting the Tests

First to remove pipes where crossing, closest to, or in contact with refrigeration coils, or where pipes are encased in ice; to remove any other piping deemed necessary.

To lower weight down riser pipes to see if clear.

Give approximate thickness of ice formed inside pipe as well as diameter of pipe. State whether ice appears snowy or hard.

On ground plans mark with solid lines any sprinkler pipes or heads found completely out of service from frost; and mark with broken lines any partly out of service and note percentage of system out of commission.

Take photographs of any interesting conditions where possible, and illustrate by drawings such conditions where photos cannot be taken. Group illustrations with the subject matter they depict, and not separately.

Take temperatures of water supplies.

Take temperature of air where it enters the system.

Object of Tests

To ascertain if ring ice formation is a necessary result from present methods of installation.

If so, the cause:

(a) From moisture pumped into system.

(b) Evaporation of priming water.

If system has been properly maintained, the precautions taken; or any suggested remedy.

Cubical Contents of a Sprinkler System

To ascertain this accurately, it will be necessary to measure up each system. Capacities of pipes in one foot lengths are as follows:

Diameter in inches	Cubic feet	U. S. gallons, 231 cu. ins.	Diameter in inches	Cubic feet	U. S. gallons, 231 cu. ins.
¾..........	.0031	.0230	3½.........	.0668	.4998
1...........	.0055	.0408	4..........	.0873	.6528
1¼..........	.0085	.0638	5..........	.1364	1.020
1½..........	.0123	.0918	6..........	.1963	1.469
2...........	.0218	.1632	8..........	.3491	2.611
2½..........	.0341	.2550	10..........	.5454	4.08
3...........	.0491	.3672	12..........	.7854	5.875

The approximate capacity can be obtained by allowing about one gallon per sprinkler. This includes riser and all distribution pipes within the risk, but does not include any long runs from the dry pipe valve to the system. This figure (one gallon per head) applies specially to systems piped from center with 75 to 115 heads on each floor. If system of 115 heads is fed from end instead of center, contents will be about 1¼ gallons per head. For large systems, with 6 inch riser and about 250 heads per floor, contents, if riser in center, will be about 1¼ gallons per head, and if riser is at one end, will be 1½ gallons per head.

Note.—If the run of pipe from the dry pipe valve to the system is in excess of 12 feet, add the capacity of this excess (by above table) to the figures and divide the total by 7.48 (the number of gallons in one cubic foot), which will give the number of cubic feet in the system.

Example.—400 sprinklers = 400 gallons; 62 ft. of 5-inch pipe from dry pipe valve to the system (50 ft. in excess of 12 ft.) adds 50 gallons, making a total of 450 gallons, which divided by 7.48 gives 60.294 cubic feet.

Amount of Moisture Pumped into System

This will depend on the humidity of the atmosphere, the tightness of the system (frequency of pumping), if there is any drying arrangement—such as a calcium chloride reservoir—and the pounds pressure raised. The following table illustrates the amount of moisture at different temperatures:

TABLE SHOWING THE WEIGHT IN GRAINS OF THE WATER CONTAINED AS VAPOUR IN 1 CUBIC FOOT OF AIR AT DIFFERENT TEMPERATURES AND PERCENTAGE HUMIDITY

Temp. °F	PER CENT HUMIDITY									
	10	20	30	40	50	60	70	80	90	100%
—20	.017	.033	.050	.066	.083	.100	.116	.133	.149	.166
—10	.028	.057	.086	.114	.142	.171	.200	.228	.256	.285
0	.048	.096	.144	.192	.240	.289	.337	.385	.433	.481
10	.078	.155	.233	.310	.388	.466	.543	.621	.698	.776
20	.124	.247	.370	.494	.618	.741	.864	.988	1.112	1.235
30	.194	.387	.580	.774	.968	1.161	1.354	1.548	1.742	1.935
40	.285	.570	.855	1.140	1.424	1.709	1.994	2.279	2.564	2.849
50	.408	.815	1.223	1.630	2.038	2.446	2.853	3.261	3.668	4.076
60	.574	1.149	1.724	2.298	2.872	3.447	4.022	4.596	5.170	5.745
70	.798	1.596	2.394	3.192	3.990	4.788	5.586	6.384	7.182	7.980
80	1.093	2.187	3.280	4.374	5.467	6.560	7.654	8.747	9.841	10.934
90	1.479	2.958	4.437	5.916	7.395	8.874	10.353	11.832	13.311	14.790
100	1.977	3.953	5.930	7.906	9.883	11.860	13.836	15.813	17.789	19.766
110	2.611	5.222	7.834	10.445	13.056	15.667	18.278	20.890	23.501	26.112

APPLICATION.—Capacity of a sprinkler system is say 60 cubic feet. With the air at 70° Fahr. and 100% humidity there will be 7.980 grains of water vapour at atmosphere pressure (14.7 lbs. per sq. inch). To raise the pressure to 40 lbs. from zero in such a system will require

$$\frac{40}{14.7} \times 60 = 163.3 \text{ cubic feet of air,}$$

which will introduce

$$\frac{163.3 \times 7.980}{7000} = .1861 \text{ lb. of water vapour,}$$

provided no change of temperature results. Most of this water will be condensed at the pump since the air is already saturated, and only that amount necessary to saturate 60 cubic feet will be introduced into the system.

Second Example.—Suppose air at 70° and 50 % humidity is pumped in, practically the same amount of moisture will be introduced since a pressure increase to 30 lbs. will cause saturation. Less moisture will be condensed, however, at the pump.

In general, it may be safe to say that the air on the high pressure side beyond the heat of compression will be saturated at whatever temperature the air passes into the cooling rooms. This, of course, may not hold on winter days, when the air temperature is low.

It will be seen, however, that moisture will be introduced into the system even if a drying tube is put in the suction pipe, because of the presence of the priming water in the dry pipe valve. It may be asked why under normal working conditions this does not dry up? The answer is obvious, when the condensation of moisture, due to the compression, is taken into account, which more than offsets any evaporation from this source into the sprinkler pipes.

In calculating the amount of moisture introduced, the temperatures should be taken in the air pipe where it enters the system, a special thermometer to be installed for this purpose. The compression pump should be in full operation and the compression heat at its maximum. When a system requires frequent pumping (daily or every few days) the sum total of the moisture introduced may be considerable.

Estimate of Amount of Moisture Pumped in and Volume of Snowy Ice Formed

In our first example we found that .186 lb. of water was introduced by the compression. Of this we may exclude all but that required to saturate the air at 70° Fahr. on the high pressure side (no more moisture can be introduced than that required to maintain the maximum vapour pressure no matter what the air pressure may be). Hence we have:

7.980 x 60
.0684 x 26 = 1.778 lb.
7000

of water vapour introduced in one pumping.

If the system is pumped up once a week for say six months (26 weeks) we have

.0684 x 26 = 1.788 lb.

of water introduced. If this were all condensed we would have 1.7 pints of water or 49.1 cubic inches.

Various estimates are given for the volume of snowy ice, compared with an equal weight of water, which range from 4 to 40 times in bulk.

Suppose we take the most conservative estimate and make the increase only four times, then the volume of snowy ice or hoar frost deposited in the pipes passing through a room kept at say—20° F. would be practically

49.1 x 4 = 196.4 cubic inches.

Referring to the next table it will be seen that this is more than enough to completely block a foot of 4 inch pipe, or three and one-half feet of 2½-inch pipe.

Now, in reality, the increase in volume when water is converted into snowy ice is generally taken as 10 times, hence it will be appreciated how easily a sprinkler system may become blocked or the pipes in the coldest rooms become seriously reduced in volume.

It should also be borne in mind that if a sprinkler system is once filled with water, it is never completely drained of moisture, since even when pipes are properly pitched, small amounts of moisture are retained at the fittings when system is set. With poorly drained systems, the amount of moisture is of course greater.

TABLE SHOWING CUBICAL CONTENTS OF PIPES IN RELATION OF ACCUMULATION OF SNOWY ICE

Diameter in inches	Capacity in cubic inches	Amount of water, when converted into snowy ice which would fill one foot length of pipe taking increase of vol. = 10 times
¾	5.357	.0742 gill
1	9.504	.132 gill
1¼	14.69	.203 gill
1½	21.25	.294 gill
2	37.67	.523 giil
2½	58.93	.815 gill
3	84.85	1.172 gills
3½	115.42	1.594 gills
4	150.83	2.083 gills
5	235.70	3.26 gills
6	339.20	4.70 gills 1.18 pints
8	603.25	8.35 gills 2.09 pints
10	942.5	13.02 gills 3.25 pints
12	1357.3	18.8 gills 4.70 pints

Under a law of physics, all moisture, either liquid or solid, will seek the places of lower vapour pressure from those of higher vapour pressure. In a dry pipe sprinkler system, the place of highest vapour pressure under normal conditions is in the dry pipe valve enclosure, and the places of lowest vapour pressure in a cold storage warehouse are the rooms with the lowest temperature (sharp freezers). Look first, therefore, for ice formation in the rooms with the lowest temperature, or where the sprinkler pipes are in contact with or in close proximity to the refrigeration coils. In an unheated building of even temperature, the ice formation is more likely to be spread uniformly throughout the entire sprinkler piping outside of the warm dry pipe valve enclosure. In a building heated on some floors, look for ice formation in the unheated sections. Same applies to unheated blind attics or roof spaces. If a system is tight and it can be ascertained by tests that very little moisture is being pumped in and the dry pipe valve has not tripped, it is reasonable to assume that if ice is found it is principally from the evaporation of the priming water with a small percentage from the moisture left in the system when drained to set dry pipe.

Formation of Hard or Black Ice and the Bursting of Pipes

When water collects in a pipe due to insufficient draining and freezes, it forms ordinary solid or black ice distinguished by its non-uniform distribution over the walls of the pipe, and more or less clear consistency. Such ice increases only slightly in volume when compared to water approximately 10%). Should the pipe be full of water before freezing takes places, bursting almost inevitably results.

Where a pipe is filled by the deposition of snowy ice from the freezing of the vapour, the crystals are deposited uniformly over the walls of the pipe, gradually closing it until only a small hole is left. When a pipe so filled becomes completely closed no extra pressure is brought into play, and no bursting should result. Snowy ice can be readily distinguished from hard or black ice

(1) by the general appearance, the former being white, and (2) by the manner of distribution in the pipe itself.

CONVERSION TABLE WEIGHT AND MEASURES

	1 gill	= 0.261 pound	= 7.29 cubic inches.
4 gills	= 1 pint	= 1.042 pounds	= 28.875 cubic inches.
2 pints	= 1 quart	= 2.084 pounds	= 57.75 cubic inches.
4 quarts	= 1 gallon	= 8.336 pounds	= 231 cubc inches, U. S. measure.
1 cubic foot		= 1728 cubic inches	= 7.4805 U. S. gallons.
1 British imperial gallon		= 10 pounds	= 1.20 U. S. gallons.

Rules for the Installation of Automatic Sprinklers in Railway Car House

To appear as section "N" in the sprinkler regulations, with consecutive numbers following section "M."

SECTION "N." RAILWAY CAR HOUSES. Foregoing rules are to be observed in protecting this class of property, and in addition thereto the special features as herein recommended are to apply.

In car houses of fire resistive construction, with all steel work protected in accordance with the requirements of the N. B. F. U., of a height not in excess of 25 feet, and with areas not in excess of 20,000 square feet, aisle line sprinklers or ceiling sprinklers, but not both, may be modified or eliminated by the inspection department having jurisdiction.

100. CEILING CURTAINS. Permanent ceiling curtains are recommended in buildings having a height of over 25 feet from floor to ceiling. These curtains may be constructed of rigidly supported noncombustible material, or of not less than 1-inch tongue and grooved boards, coated on both sides with standard fire retarding paint; curtains to sub-divide ceiling into pocket areas not exceeding 5,000 square feet each, and to be of a depth from ceiling to trolley wire. Inspection department having jurisdiction should be consulted as regards the specific location of these curtains.

101. AISLE SPRINKLERS. (a) In addition to the regular ceiling installation, sprinklers shall be placed on both sides of each track, in an upright position, on horizontal pipe lines parallel with tracks, and shall be so located that water will spray directly into cars through side windows of car bodies; the sprinklers must be at such a height that their deflectors will be from two to four inches below the upper sash rail of car windows.

(b) When the distance between sides of cars on adjacent tracks does not exceed 4 feet, one line of sprinklers shall be placed in the center of each aisle between tracks.

(c) When the distance between sides of cars on adjacent tracks exceeds 4 feet, two lines of sprinklers must be installed. Sprinklers shall not be placed less than 6 inches nor more than 12 inches from the sides of cars to be protected.

(d) When the distance between the sides of cars on adjacent tracks is less than 12 inches, or where aisle lines in accordance with this section may not be practicable, as at curves, switches, transfer tables, car elevators, repair and paint shops, special instructions from inspection department having jurisdiction should be obtained as regards installing raised or altered lines.

(e) Sprinklers must be placed between cars and partitions, division or outer walls, not less than 6 inches nor more than 12 inches from the sides of cars to be protected.

(f) Distance between sprinklers on aisle lines shall not exceed 8 feet.

(g) The standard pipe schedule shall govern installations of aisle lines, except that no pipe smaller than one inch may be used.

(h) Sprinklers on all aisle lines shall be staggered spaced.

102. SUPPLY MAINS TO AISLE SPRINKLERS. (a) Ceiling and aisle sprinklers shall be installed upon separate dry valves or alarm valves.

(b) In small car houses or sections of an area not great enough to require at least two dry valves, ceiling and aisle lines may be installed; supplied by one dry valve, in which case separate connections are to be taken from above and close to the dry pipe valve, and shut-off valves shall be provided for ceiling and aisle systems, so arranged that either may be controlled independently.

(c) Aisle lines must not be supported by nor connected to ceiling sprinkler piping. Special hangers or supports must be provided that aisle lines may be rigidly secure.

(d) Troughing shall be installed over trolley wires in such a manner as to preclude the possibility of a short circuit being caused, between grounded metal work and trolley wire, by the trolley pole.

103. PITS AND UNDER FLOOR SPACE. Where the under floor space does not communicate with the pits, is tightly enclosed, and is not used for any purpose, sprinklers may be omitted in such under floor space by special consent, in each instance, of the inspection department having jurisdiction.

Suggested Amendments to Present Regulations

(See edition of 1915)

SECTION "C." RULE 16. Partitions—to add a second paragraph reading as follows:

"Where no inflammable material is stored close to the ceiling, the inspection department having jurisdiction may waive the requirement for providing extra sprinklers in narrow pockets formed by beams and partitions where the construction is entirely fireproof, including the partitions."

SECTION "E." RULE 25. Supporting of Risers—to add to the present third paragraph at foot of page 15 a new paragraph as follows:

"In lieu of floor plates and couplings as called for above, extra hangers near the risers and so arranged as to properly support the weight, may be accepted."

SECTION "H." DRY PIPE SYSTEM AND FITTINGS. Preceding present rule 54, to insert a new one reading: "Anti-Columning Pipes. When anti-columning pipes are used, they shall be either lead lined or of brass."

RULE 56. Flanged Dummy—to change same to read:

"A flanged section of pipe with drain outlet same size as dry pipe valve, to take the place of dry pipe valve, in case of repairs, should be provided for each type and size installed, and kept at the valve."

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NOTE.—On pages 24 to 47 inclusive is an alphabetical list of substances, with their principal hazards mentioned, as compiled by the Bureau of Explosives of the American Railway Association; likewise, under Manufacturing Hazards, pages 48 to 96, is an alphabetical list of processes, appliances and materials; reference should also be made to these, as the index below does not include all of the articles mentioned.

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ROOFINGS.—The Underwriters' Laboratories, since the date of printing the major part of this book, have reclassified the grading of Roof Coverings as given herein on page 362. As now classified there are three classes, A, B and C; roughly, Class A includes former Classes A and B; Class B includes former Classes C and D, and Class C includes former Classes E and F.

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